WADC TECHNICAL REPORT 58-326
ASTIA DOCUMENT NO. AD 155865

TENSION-TENSION FATIGUE INVESTIGATION OF HIGH STRENGTH AIRCRAFT BOLTS EFFECT OF NUT ENGAGEMENT AND THREAD ROOT RADIUS

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STANDARD PRESSED STEEL COMPANY
JENKINTOWN, PENNSYLVANIA

FEBRUARY 1958

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AIRCRAFT LABORATORY
WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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PROJECT 1318
TASK 13444

AIRCRAFT LABORATORY
WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

McGregor & Werner Midwest Corp., Dayton, O.
[illegible]

FOREWORD

This report was prepared by Standard Pressed Steel Co., Jenkintown, Pennsylvania, under United States Air Force Contract No AF 33(616)-3646. This contract was initiated under Project No. 1318, Task No. 13444. The work was administered under the direction of the Special Project Branch, WCLSJ-3, Aircraft Laboratory, Wright Air Development Center with Mr. A. B. Nutt, Branch Chief; Mr. J. W. Evans, Section Chief; Mr. F. A. Hannon, Project Engineer.

This report covers the period of work from April 2, 1956 to February 15, 1958.

ABSTRACT

The object of this project was to establish the tension-tension fatigue properties of external threads without the influence of stress concentrations resulting from engagement; and further, to compare the fatigue characteristics of bolts to those of unengaged threads. These comparisons were to be made on parts heat treated to two strength levels, 160,000 psi and 220,000 psi. Also, fatigue properties of the higher strength parts with thread roots to MIL-B-7838 and high radius thread roots were to be compared.

A stud with a reduced diameter threaded section in the center was developed to evaluate the fatigue characteristics of unengaged threads. The bolts used to determine the fatigue properties of engaged threads conformed to MS 20004 series and SPS EWB 22 dimensions. The nuts used were SPS 42 FW and SPS EWN 22 type without slots or locking action. Fatigue tests were also run using standard self locking all metal nuts and those with a non-metallic locking element.

S-N tension-tension fatigue curves were developed on studs and bolts heat treated to 160,000 psi and 220,000 psi. These were made from the following materials: AISI 8740, AISI 6150, AISI 4340, Hy Tuf and VascoJet 1000. The test thread diameters ranged from 1/4 inch to one inch.

Threads were formed by each of these methods: cutting, grinding and rolling after heat treatment. Tests were run on both studs and bolts with the thread root radii conforming to MIL-B-7838 and with high radius thread roots.

All bolts were cadmium plated. The studs were tested with and without plating. The tension-tension fatigue tests showed:

1. The fatigue strength of unengaged threads is 1 1/4 to 2 1/2 times greater than the engaged threads.
2. By increasing the material strength from 160,000 psi to 220,000 psi (1.4 times) the fatigue strength increases 1.2 to 2.8 times.
3. The fatigue strength of the high radius thread is 1.4 times greater than the MIL-B-7838 thread.
4. All metal locknuts yield higher bolt fatigue strength than those with non-metallic locking elements.
5. Plating reduces the fatigue strength of threads about 15%.
6. The fatigue strength of unengaged threads rolled after heat treatment is 1 1/2 to 2 times greater than cut or ground threads under similar conditions.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

JH Harrington

for RANDALL D. KEATOR
Colonel, USAF
Chief, Aircraft Laboratory
Directorate of Laboratories

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SECTION I

INTRODUCTION

Rapidly increasing speeds of aircraft and missiles demand increased static and dynamic properties per pound of material. This objective may be gained by three different methods.

a. The development of alloys with higher strength-to-weight ratios.
b. The development of processing methods to attain increased properties from existing alloys heat treated to higher strengths.
c. The design of parts to utilize an increased percentage of the inherent properties of the alloy.

At the present time progress is being made to develop alloys with greater strength-to-weight ratios. The titanium alloys presently being used are a step in this direction. New alloys of both titanium and other elements are being developed, but these will require time to evaluate and further develop for commercial applications.

While this alloy development progresses, techniques of processing to increase the strength-to-weight ratio must be continued. In this manner, even greater improvement may be achieved with the use of the new alloys. Two of the improvements realized in recent years through fabrication procedures are increased strength and fatigue life. These have resulted from the selection of existing materials which have higher strength with good ductility and the development of production methods to produce threads on hardened alloys.

Additional gains in the strength-to-weight ratio can be achieved by utilizing designs which provide an increased percentage of the inherent properties of the alloy. Studies of the stress distribution in structural elements have disclosed points of high stress concentration located in areas where the stress had been estimated to be at a minimum. In other instances, it has been known that stress concentrations existed but their effect has never been determined. Design criteria developed from these studies will be applicable when new alloys and fabrication techniques are developed. Thus, an additional gain in the strength-to-weight ratio may be realized.

Since threaded fasteners are used in many applications on aircraft, a test program was established by the Aircraft Laboratory, Wright Air Development Center, to determine some of the dynamic properties of threaded fasteners. Basically, the object of the project was to determine the tension-tension fatigue characteristics of:

a. present high strength aircraft bolts

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b. unengaged threads
c. the high radius thread form
d. plated threads
e. cut threads
f. ground threads

The bolts tested were heat treated to 160,000/180,000 and 220,000/240,000 psi. The studs with unengaged threads were fabricated to the same strength levels. The thread forms tested were fabricated in accordance with MIL-B-7838 and with high radius threads. These threads were tested on bolts in conjunction with nuts and on studs so designed that the threads were not engaged.

SECTION II

TEST PROGRAM

This test program was set up to evaluate the static and dynamic characteristics of threads. Comparisons were made between the tension-tension fatigue strengths of threaded assemblies and unengaged male threads. Threaded parts 1/4 to one inch diameter were tested. The threads were produced by a single rolling operation on studs and bolts heat treated to 160,000/180,000 psi and 220,000/240,000 psi. In addition, an evaluation was made of the fatigue strength of unengaged male threads produced by cutting and grinding. A comparison of two modifications in the MIL-S-7742 thread form, which consisted of different size radii in the thread root, were conducted on the high strength parts. Since alloy steel bolts are usually cadmium plated for corrosion resistance, the effect of this coating on the fatigue life was determined.

Bolts were fabricated to standard configurations. All metal nuts were used in determining the static and fatigue properties of the bolts. Additional tests were conducted using all-metal and non-metallic insert locknuts to determine if there was any difference in the fatigue life of a threaded assembly due to the design of the locking element of the nut.

The fatigue properties of unengaged male threads were determined on studs which had the test thread located in the center. The goal of the stud design was to develop a part which would fail in fatigue near the center of the male test thread. Thus the influence of stress concentrations resulting from nut engagement and thread termination could be eliminated. However, it was not found possible to completely eliminate the effect of thread runout.

The bolts and studs heat treated to 160,000/180,000 psi were fabricated from MIL-S-6049 (AISI 8740) alloy in all sizes except the one inch which was made from MIL-S-5000 (AISI 4340) alloy. The 220,000/240,000 psi parts were fabricated from MIL-S-8503 (AISI 6150), MIL-S-7108 (Hy Tuf) and Vasco-Jet 1000.

Each lot of parts was subjected to static and dynamic tests to determine their properties. The following static tests were conducted on each lot of bolts.

a. Tensile strength of the threaded fastener.
b. Yield strength of the threaded fastener.
c. Shear strength of the bolt body.
d. Tensile strength of the base material.
e. Yield strength of the base material.
f. Percent elongation of the base material.
g. Percent reduction of area of the base material.

The static mechanical properties of the base material of each lot of studs were determined. Tensile tests were conducted on some lots of studs, but these tests were discontinued because fracture did not occur in the test section.

Tension-tension fatigue tests were conducted at five stress levels on all lots of bolts and studs. Four stress levels were selected to produce failures between 10,000 and 4,000,000 cycles. Five pieces were tested at each of these stress levels. The fifth stress level was selected to produce 8,000,000 cycles with no failure. Two pieces were tested at this stress level.

SECTION III

TEST PIECES

A. BOLT:

The 160,000/180,000 psi bolts were made in 1/4, 5/16, 3/8, 1/2, 5/8, 3/4 and one inch diameters to MS 20004 series dimensions, Figure 1. The threads were produced on the hardened and ground parts by a single rolling process to the dimensions, form and contour shown in Specification MIL-B-7838. All diameters except the one inch were fabricated from MIL-S-6049 (AISI 8740) alloy. The one inch diameter was made from MIL-S-5000 (AISI 4340) alloy. The bolts were cadmium plated to Specification QQ-P-416, Type 1, Class C and baked at 375°F ±25°F for a minimum of three hours.

One group of 220,000/240,000 psi bolts was made in [illegible], 3/8, 1/2, 3/4 and one inch diameters to SPS EWB 22-4 series dimensions, Figure 2. The threads were produced on the hardened and ground parts by a single rolling process to the dimensions, form and contour shown in Specification MIL-B-7838. All these bolts were fabricated from MIL-S-7108 (Hy Tuf) alloy. They were cadmium plated from a fluoborate bath in accordance with Specification NAS 672 and baked at 375°F ±25°F for a minimum of 23 hours. This type plating was used to reduce the possibility of embrittlement due to hydrogen.

One lot of 1/4-28 bolts heat treated to 220,000/240,000 psi were made to MS 20004 dimensions, Figure 1. The threads were produced on the hardened and ground parts by a single rolling process to the dimensions, form and contour shown in Specification MIL-B-7838. These bolts were fabricated from MIL-S-8503 (AISI 6150) alloy. These bolts were cadmium plated to Specification QQ-P-416, Type 1, Class C and baked at 375°F ±25°F for a minimum of three hours.

The 220,000/240,000 psi bolts were also made in 1/2 and 3/4 inch diameters to SPS EWB 22-4 series dimensions, Figure 2. The threads were produced on the hardened and ground parts by a single rolling process to the dimensions, form and contour of the high radius thread form. These bolts were fabricated from MIL-S-7108 (Hy Tuf) alloy. They were cadmium plated from a fluoborate bath in accordance with Specification NAS 672 and baked at 375°F ±25°F for a minimum of 23 hours.

One lot of 1/2-20 bolts heat treated to 220,000/240,000 psi were made to SPS EWB TM 9-4 series dimensions, Figure 3. The threads were produced on the hardened and ground parts by a single rolling process to the dimensions, form and contour of the high radius thread form. These bolts were fabricated from a 5% Cr die steel (VascoJet 1000). The bolts were

nickel-cadmium diffused plated in accordance with Specification AMS 2416. This plating was used to provide corrosion resistance up to 1000°F.

B. STUDS:

To determine the tension-tension fatigue properties of unengaged threads, it was necessary to develop a test specimen. The goal of this design was to produce fatigue failures in the center portion of the test threads. To achieve this, the effect of stress concentrations at the thread termination and those due to the nut engagement had to be eliminated. Therefore, the test thread could not be loaded through a nut and the effect of thread termination had to be minimized. Various designs of specimens described below were fabricated and tested. It was found impossible to eliminate entirely the effect of the thread termination. However, in the design adapted, the effect of the thread runout was minimized. Failures occurred predominantly in the last full thread except in the case of the cut and ground threads where fractures occurred near the center of the threaded portion.

The basic shape of all specimens was a stud with a reduced threaded section in the center. All development work on stud design was carried out on parts fabricated from AISI 8740 material heat treated to 160,000/180,000 psi. The thread form used conformed to MIL-B-7838 and was rolled subsequent to heat treatment.

The initial design, Figure 4, had a 1/2-20 thread on each end with a 3/8-24 thread in the center. The radius joining the two threads, the 1/2 inch to the 3/8 inch, was made tangent to the root of the smaller thread. A .065 inch radius fillet blended this to the thread. In fatigue, failure of the 1/2-20 thread occurred prior to the 3/8-24, Figure 5. In all subsequent designs, the threads on the ends of the studs were made twice the diameter of the test thread.

Since fatigue occurred first in the 1/2-20 thread, it was decided to conduct all future tests for design development on studs with 1/2-20 threads on the end and 1/4-28 MIL-B-7838 threads in the center. All such parts were made from AISI 8740 material heat treated to 160,000 psi minimum tensile strength.

The first stud of this design was made with a six inch radius blending the two threads and tangent to the 1/4-28 thread at its major diameter. The dimensions are shown in Figure 6. Special thread roll dies were made, as shown in Figure 8, to produce the thread between two runout angles. As shown in Figure 7, failure occurred at the thread runout.

Next, studs were made with the six inch radius blending the two threads tangent to the pitch diameter of the smaller thread. Figure 9 shows the

dimensions of the parts. Fatigue failure occurred at the thread termination as shown in Figure 10.

These parts were modified as shown in Figure 11 by machining a 3/16 radius at the termination of the test thread. This fillet was tangent to the thread root and was cold worked by forcing a roller against the radius. Figure 12 shows the fatigue failure located in the 3/16 radius.

The next stud design had the six inch radius tangent to the thread root. The 1/4-28 thread was rolled before grinding the six inch radius. Two full threads at each end of the smaller thread were ground off when finishing the six inch radius. This was made tangent to the thread root as shown in Figure 13. Fatigue fracture occurred in the first full thread from the termination as shown in Figure 14.

To try and reduce the stress in the thread termination area further so that fatigue failure would occur nearer the center, a new design was tried. This is shown in Figure 15. The thread runout was tapered from the full thread form to the six inch radius which was tangent to the major diameter of the test thread. The shape of the dies used is shown in Figure 16. As shown in Figure 17, fatigue failure occurred at the junction of the taper and the full thread form.

Figure 18 shows the design of the next stud tested. A uniform taper blended the major diameter to the root diameter. Standard thread roll dies 1.952 inches wide were used to thread these parts. The fatigue failure occurred at the junction of the tapers from the 1/2 inch thread and the 1/4 inch thread, as shown in Figure 19.

The final design tested is shown in Figure 20. A 1/4-28 thread form was planned on a five inch radius. The axis of each thread was perpendicular to the axis of the stud. A satisfactory thread form could not be produced due to the difference in surface speeds between the die and the part along the contour. The special thread roll dies made to produce these parts are shown in Figure 21. As shown in Figure 22, the thread was not fully formed over the entire length and had a protruding sliver of metal. Etched specimens showed laps and very rough surfaces. A satisfactory thread could not be produced.

At a meeting held at Wright Air Development Center, it was decided to discontinue further stud develpment and use the design shown in Figures and 14. This was the only design which produced fatigue failures in the fully formed threads. The fractures were located in the last full thread before the run out thread. Studs of all sizes were fabricated to the dimensions shown in Figure 23.

The steel specimens were produced in two strength levels, 160,000/180,000 psi and 220,000/240,000 psi. The lower strength parts were fabri-

cated from MIL-S-6049 (AISI 8740) with test thread diameters of 1/4, 3/8, 1/2 and 3/4 inch. The one inch size was fabricated from MIL-S-5000 (AISI 4340) material. The threads on these sizes were produced by a single rolling process on the hardered and ground studs. The thread form conformed to MIL-S-7742 as modified by MIL-B-7838, Table 1 and Figure 24. The 3/4 inch size was also produced with both cut and ground threads. The threads were cut before heat treating and conformed to MIL-S-7742. The root of the thread was flat with small radii blending to the flanks, Figure 25. The ground threads were produced after heat treatment with root radii rounded to MIL-B-7838.

Some of the 1/4, 3/8 and 3/4 inch test threads at 160,000 psi with rolled threads were cadmium plated to Specification QQ-P-416, Type 1, Class C. These were baked at 375°F for 3 hours to remove hydrogen.

Higher strength level, 220,000/240,000 psi, specimens were fabricated from MIL-S-7109 (Hy Tuf) material with test thread diameters of 1/4, 3/8, 1/2, 3/4 and one inch. Also, a lot was produced in the 1/4 inch size from MIL-S-8503 (AISI 6150) material. Threads were produced by a single rolling operation on the hardened and ground studs. The thread form conformed to MIL-S-7742 as modified by MIL-B-7838, Table 1. The 1/2 and 3/4 inch sizes were also fabricated with the high radius thread, Figure 26 and Table 2. Test specimens with rolled threads in the 1/4, 3/8 and 3/4 inch size at 220,000 psi were cadmium plated from a fluoborate bath to Specification NAS 672. These were baked at 375°F for 23 hours to remove hydrogen. Studs with the 3/4 inch size threads were also made by cutting and grinding. The threads were cut to MIL-S-7742 before heat treating. The root was flat with small radii blending to the flanks, Figure 23. The MIL-B-7838 thread form was ground after heat treatment.

A lot of 1/2-20 studs were produced from a 5% chromium hot work die steel, VascoJet 1000 and were heat treated to 220,000/240,000 psi. The high radius thread form was rolled after heat treatment.

C. NUTS:

The locknuts tested in fatigue to evaluate the effect of design were standard external wrenching nuts for 160,000 psi bolts. The all metal designs were the SPS 42FW 524 and 42FW 1018. The nuts with a non-metallic locking element were the ESNA EB0524 and EB 1018.

TABLE I

Thread Root Radii Specified in MIL-B-7838

Size	Radius(inch) Minimum	Maximum
1/4	.0040	.0051
5/16	.0050	.0060
3/8	.0050	.0060
1/2	.0060	.0072
5/8	.0060	.0080
3/4	.0070	.0090
1	.0080	.0103

TABLE II

Thread Root Radii Specified for High Radius Thread

Size	Radius (inch) Minimum	Maximum
1/2	.0078	.0090
3/4	.0092	.0112

SECTION IV

TEST EQUIPMENT

A. TENSILE:

1. Machines

Tinius Olsen Universal Testing Machines which were used in this project had the following capacities:

Max. Capacity-#	Additional Tensile Ranges	Type Operation	Figure
30,000	6,000; 1,200; 300	Electomatic	27
60,000	12,000; 1,200	Hydraulic	28
120,000	24,000; 6,000; 1,200	Electomatic	29
400,000	80,000; 20,000	Hydraulic	30

The electomatic machines operate by a variable speed motor driving the loading screws. The load is measured through a lever system and load cells consisting of differential transformers on a beam. The guaranteed accuracy of these machines is $\pm 1\%$.

The hydraulic machines are loaded by fluid pressure. The load is measured through differential transformers on sensitive Bourdon tubes. The guaranteed accuracy of these machines is also $\pm 1\%$.

All tensile machines were calibrated using proving rings certified by the U. S. Bureau of Standards. The rings shown in Figure 31 have the following capacities:

3,000 pounds
30,000 pounds
300,000 pounds

2. Accessories

Each machine is equipped with the following accessories:

a. Pacer - to control loading at a fixed rate in pounds per minute.
b. Recorder - to plot load in pounds vs extension.
c. Strain rate indicator - to control loading at a fixed strain rate.

All tests were run with one of the extensometers shown in Figure 32. The extensometer in the lower left corner was used to measure the elong-

ation of bolts in inches. The "S" series of extensometers was used to measure smooth specimen elongation in inch per inch. The particular gage lengths used for the specimen were 0.50, 1.0, 1.4 and 2.0 inches. An application of the extensometer on a specimen may be seen in Figure 33. Figure 34 shows how the bolt extensometer is used on bolts up to fifteen inches long.

The lever arm of the extensometers actuates the differential transformer, which in turn transmits the signal to the recorder. In this way the elongation is plotted on the recorder according to the magnification selected on the recorder panel. Each extensometer has three magnification ranges. These ranges vary from 50 to 1000 depending on the extensometer used.

To accurately locate the bolt extensometer, a center drill hole is made at the point and in the head recess or socket. This gives point contact. The specimen extensometers are put directly on the smooth gage section of the piece. The gage length used for specimens was four times the gage diameter. The guaranteed accuracy of the recorder is $\pm 1\%$.

3. Fixtures

To attain the required alignment for accurate values, fixtures fabricated to close tolerances were used for tensile testing.

The links used are shown in Figures 35 thru 39. These were also used in fatigue testing. With the use of adapters, Figures 40 thru 42, these links provided a means to test from 1/4 to 1 1/2 inch diameters. Both the links and the adapters were fabricated within very close tolerance to insure axial loading.

Bolt and nut combinations were pulled in tensile with links and adapters at both ends. The stud specimens were pulled with the link set up on one end and a tapped bar on the other. The tapped bar was held in the tensile machine by jaws. The tapped bars are pictured in Figures 43 and 44.

The drawings, Figure 45 and 46 show the top and bottom of the room temperature shear die. The set up is shown in Figure 47. The shear tests were run in the Universal Testing Machines.

B. FATIGUE:

1. Machines

Fatigue machines of the following models and capacities were used to test the bolts and studs of this program:

a. 5,000 pound Krouse operating at 1650 CPM, Figure 48.
b. 15,000 pound Krouse operating at 1050 CPM, Figure 49.
c. 60,000 pound Ivy operating at 1200 CPM. Figure 50.
d. 60,000 pound Krouse operating at 850 CPM, Figure 51.
e. 220,000 pound Amsler operating at 500 CPM, Figure 52.

Load multiplying fixtures were used on a 15,000 pound Krouse and the Ivy machine to produce 60,000 pounds.

The 5,000 and 15,000 pound Krouse machines operate on the principle of an adjustable throw crank applying the alternating load to the specimen thru a lever and a parallelogram of flexture plates. The minimum load is applied by a hydraulic cylinder attached to a stationary holder. During the test, constant load limits are maintained on the specimen by electrical contacts on the lever. These contacts operate solenoids which permit oil to flow to the hydraulic cylinders. In this manner, the loads can be maintained within $\pm 2\%$ at all times.

The 60,000 pound Krouse is basically the same machine as the 15,000 pound Krouse. The load is applied to the specimen through 4:1 multiplying levers, Figure 51.

The 12,000 pound Ivy machine is an inertia-compensated machine that develops the alternating force by rotating an adjustable mass. The static load is applied through a torsion bar. The loads are applied by means of an oscillating beam. The load multiplier increases the capacity five times. Since the dynamic load alternates about the mean static load, the static load is controlled to maintain the load limits within $\pm 2\%$. This is done by a reluctance gage and an electronic circuit.

The 220,000 pound Amsler machine applied all loads by hydraulic pressure. The loads are maintained within $\pm 2\%$ at all times by electric contacts on pressure gages.

2. Fixtures

The adapters and links provided a method for testing both studs and bolts of different diameters in the same machine. Figure 53 shows the basic tension-tension fatigue set up using a bolt, adapters, links and washer.

Links were made in various sizes ranging from 3,000 to 220,000 pound maximum capacity as shown in Figures 35 thru 37 and 54. The tolerances of squareness and concentricity were held to very close limits to insure uniaxial loading. In this way alignment is built into the set up and not left up to the operator. The design of the links meets the requirements of NAS 1069.

The adapters used in the links are shown in Figures 40 thru 42. Note that the tolerances of squareness, concentricity and size were held to a practicable minimum to insure uniaxial loading. Figures 55 and 56 show the adapters used to test the threaded studs when nuts were not used.

Originally all links were fabricated in accordance with Specification NAI 160 "Tension-Tension Fatigue Test Standardization", October 1956. These are shown in Figures 57, 58 and 59. Threaded adapters to mount these links on the 60,000 pound Krouse are shown in Figure 60 and 61. However, failure of the links at low cycles and low loads forced the use of the links as shown in Figure 52. Figures 62 and 63 show where the failure occurred in the large (200,000 pound) NAI link at 173,200 cycles under a 90,500 pound load. Figure 64 shows failure of the 15,000 pound NAI link. The design of these NAI links have since been changed to increase the fatigue life. The NAI 160 specification has been superseded by NAS 1069.

3. Load Measuring

The loads were measured by resistance strain gages bonded to the loading column, Figure 65. To insure accuracy, the gages were calibrated under dynamic loading to develop a machine constant. A calibrated load cell was used.

Figure 66 shows the electronic equipment used to measure the output from the strain gages. These units are from left to right.

a. Baldwin or Ellis Associates, six channel switching and balancing unit. This provides a convenient method of balancing the individual circuits and switching from one set of gages to another.

b. Ellis Associates, BA-12 Bridge and Amplifier. This unit supplies DC power to the circuit, amplifies the output from the gages and provides a means of measuring the strain at the gage location. Basically, it completes the Wheatstone bridge of the circuit with various precision resistors to provide different ranges of operation. The chopper circuit, in which the output is controlled by a variable precision resistor adjusted by an indicating micrometer screw, provides the means of measuring the gage output accurately.

c. DuMont Type 304 A or 350 Oscillograph with a P-7 screen. Through this instrument a means of visual adjustment of the measuring circuit, as well as a picture of the loading cycle, is possible.

Measurements of loads are taken by adjusting the variable precision resistor on the amplifier unit by a micrometer screw until the horizontal line on the oscillograph is tangent to the peak or trough of the load line wave.

Figure 67 shows a typical pattern on the oscilloscope. The horizontal measuring line is shown at zero stress. The readings on the micrometer are multiplied by the constant derived by calibration for that machine.

All cables were shielded with a metal covering. The shielding and all instruments were grounded to eliminate fuzziness and distortion from the oscilloscope pattern.

C. NUTS:

The 160,000 psi bolts were tested with the fatigue nuts shown in Figure 68. Another fatigue nut, Figure 69, was used to test the 220,000 psi bolts. The studs were tested with nuts and with threaded bushings.

Special 1 3/4" and 2" nuts, Figure 70, were used to test the one inch unengaged threads.

All nuts varied from standard because they had neither locking device nor plating. The squareness of the bearing face with respect to the axis of the pitch diameter was .003 inch TIR maximum.

To test the effect of nut locking devices on fatigue life, tests were run with SPS 42 FW 524 and SPS 42 FW 1018 nuts, Figure 71 and ESNA EB 524 and EB 1018, Figure 72. The SPS nut had a metallic locking device, while the ESNA nut had a non-metallic insert.

D. WASHERS:

To prevent the head-to-shank fillets from bearing directly on the adapters, countersunk washers per SPS WC 22, Figure 73, were used under the bolt heads for all tests. No washers were used under the nuts.

SECTION V

TEST PROCEDURES

A. TENSILE:

After fabrication all parts were dimensionally inspected to the applicable print. The thread form, contour, and dimensions were particularly noted as to their conformance to specification requirements.

The bolts made for this test program are listed in Table IV. The studs tested are listed in Table V.

Two smooth specimens of each lot of bolts and studs were pulled in tensile to determine the static mechanical properties of the base material of the finished part. The specimens were fabricated to sizes listed in "Federal Test Standards", No. 151, published July 17, 1956. The gage sizes used for each thread diameter tested are given in Table III.

TABLE III

Gage Sizes for Parts Tested in Tensile

Nominal Thread Diameter	Gage Diameter	Gage Length
1/4	.113	0.45
3/8	.252	1.0
1/2	.357	1.4
3/4	.505	2.0
1	.505	2.0

The ultimate strength of all parts was obtained directly from the dial on the tensile machine. The yield strength of the specimens was determined by the 0.2% offset method. Elongation and reduction of area were calculated from direct measurement. Results of all tests are reported in Appendices I and II

Extensometers of the appropriate gage length were used on all specimens tested as shown in Figure 33.

Two bolts of each lot were pulled in tensile to obtain the ultimate and yield strengths. The overall bolt extensometer was used to plot the load extension curves as shown in Figure 34. The yield strength was determined as that point where the slope of the plastic region of the load extension curve is equal to 2/3 the slope of the elastic range of the same curve. Tensile tests were not run on the studs since failure occurred in the shank rather than the threaded portion.

TABLE IV

Bolts Tested for Mechanical Properties
160,000 psi Heat Treatment

Diameter	Configuration	Material	Thread Form
1/4-28	MS 20004	MIL-S-6049	MIL-B-7838
3/8-24	MS 20006	MIL-S-6049	MIL-B-7838
1/2-20	MS 20008	MIL-S-6049	MIL-B-7838
3/4-16	MS 20012	MIL-S-6049	MIL-B-7838
1-14	MS 20016	MIL-S-5000	MIL-B-7838

220,000 psi Heat Treatment

Diameter	Configuration	Material	Thread Form
1/4-28	EWB 22-4	MIL-S-7108	MIL-B-7838
1/4-28	MS 20004	MIL-S-8503	MIL-B-7838
3/8-24	EWB 22-6	MIL-S-7108	MIL-B-7838
1/2-20	EWB 22-8	MIL-S-7108	MIL-B-7838
1/2-20	EWB 22-8	MIL-S-7108	High Radius
1/2-20	EWB TM 9	VascoJet 1000	High Radius
3/4-16	EWB 22-12	MIL-S-7108	MIL-B-7838
3/4-16	EWB 22-12	MIL-S-7108	High Radius
1-14	EWB 22-16	MIL-S-7108	MIL-B-7838

TABLE V

Studs For Testing Mechanical Properties of Unengaged Threads

160,000 psi Heat Treat

Diameter	Material	Thread Form	Thread Formed By	Plate
1/4-28	MIL-S-6049	MIL-B-7838	rolling	None
1/4-28	MIL-S-6049	MIL-B-7838	rolling	Cadmium (Cyanide)
3/8-24	MIL-S-6049	MIL-B-7838	rolling	None
3/8-24	MIL-S-6049	MIL-B-7838	rolling	Cadmium (Cyanide)
1/2-20	MIL-S-6049	MIL-B-7838	rolling	None
3/4-16	MIL-S-6049	MIL-B-7838	rolling	None
3/4-16	MIL-S-6049	MIL-B-7838	rolling	Cadmium (Cyanide)
3/4-16	MIL-S-6049	MIL-B-7838	grinding	None
3/4-16	MIL-S-6049	MIL-B-7838	cutting*	None
1-14	MIL-S-5000	MIL-B-7838	rolling	None

220,000 psi Heat Treat

Diameter	Material	Thread Form	Thread Formed By	Plate
1/4-28	MIL-S-7108	MIL-B-7838	rolling	None
1/4-28	MIL-S-7108	MIL-B-7838	rolling	Cadmium (Fluoborate)
1/4-28	MIL-S-8503	MIL-B-7838	rolling	None
3/8-24	MIL-S-7108	MIL-B-7838	rolling	None
3/8-24	MIL-S-7108	MIL-B-7838	rolling	Cadmium (Fluoborate)
1/2-20	MIL-S-7108	MIL-B-7838	rolling	None
1/2-20	MIL-S-7108	High Radius	rolling	None
1/2-20	VascoJet 1000	High Radius	rolling	None
3/4-16	MIL-S-7108	MIL-B-7838	rolling	None
3/4-16	MIL-S-7108	MIL-B-7838	rolling	Cadmium (Fluoborate)
3/4-16	MIL-S-7108	High Radius	rolling	None
3/4-16	MIL-S-7108	High Radius	rolling	Cadmium (Fluoborate)
3/4-16	MIL-S-7108	MIL-B-7838	grinding	None
3/4-16	MIL-S-7108	MIL-B-7838	cutting*	None
1-14	MIL-S-7108	MIL-B-7838	rolling	None

* Threads cut before heat treatment; all other threads formed after heat treatment.

All tensile tests were run at a rate of 65,000 psi per minute. The tensile machines were calibrated with proving rings certified by the Bureau of Standards.

B. SHEAR:

Double shear tests were conducted on the shanks of two bolts of each lot. The shear die set up is shown in Figure 47. The rate of loading was 100,000 psi per minute.

C. FATIGUE:

Each lot of studs and bolts was run in tension-tension fatigue to develop a full S-N curve with four stress levels between 10,000 cycles and the endurance limit. Five pieces were tested at each stress level. Pieces were run to determine the 8,000,000 cycle endurance limit, and two pieces were tested at that stress level.

Cadmium plated studs were fatigue tested at a minimum of two stress levels. These levels were selected to determine the relative location of the S-N curves.

In all fatigue tests the low load was ten percent of the maximum load. Loads were maintained within $\pm 2\%$ by the various methods described in the section on Test Equipment. Fatigue stress calculations were based on the tensile stress area(1), and plotted values were maximum stresses.

In setting up a fatigue specimen, it is extremely important that the alignment and squareness of the adapters be as accurate as possible to insure uniaxial loading. Therefore, it was standard procedure to check the following:

a. That the adapters sat squarely in the links without rocking.
b. That the part slid freely through the adapters at both extremes of the stroke.

(1) The tensile stress area is calculated by the equation -

$$A = 3.1416\,(E/2 - 3H/16)^2$$

where A = Tensile stress area
E = Basic Pitch Diameter
H = Height of sharp V thread

The term 3H/16 is equal to 1/2 the addendum of the external thread. The tensile stress areas are listed in Table I. 3, page 129 of "Screw-Standards for Federal Services" 1957 Handbook H-28.

The first piece of any lot run at a particular stress was assembled into the machine and adjustments of the loading mechanism were made until the required loads were attained. This piece was run to failure and examined for indications of bending, as follows:

a. Bending is indicated by the fatigue fracture progressing from one side of the part to the final tensile fracture, which is located on the opposite side of the origin, Figure 74.
b. Uniaxial loading results in a fracture that shows fatigue crack propagation from all sides of the part toward the center, Figure 75. Note the difference in appearance between Figures 74 and 75.
c. Severe bending is indicated by rubbing marks on the body of the bolt where it engaged opposite sides of one of the adapters, Figure 76.
d. If, in other samples tested, the location of the start of the fatigue crack is always located at the same relative position to the link and adapter, then the loading is not uniaxial.

1. Plotting of Data

The fatigue data were plotted on semi-logarithmic paper. The maximum stress based on the tensile stress area was plotted as the ordinate and the cycle life was plotted as the abscissa on a logarithmic scale.

The load in pounds was shown on the left hand side of the chart. The results of each test were plotted and the curve of best fit was drawn through the logarithmic mean lives. These were computed by the equation

$$\frac{\text{Log } X_1 + \text{Log } X_2 + \text{Log } X_3 + \text{Log } X_4}{n} = \text{Log } \bar{X}$$

where X = Test result at a given stress level
n = Number of Specimens tested at that stress level
$\bar{X}$ = Logarithmic Mean Life

SECTION VI

SUMMARY OF RESULTS

The raw data for all tests are presented in the Appendices. The tensile properties of the parts and base material are tabulated on data sheets for each lot of pieces. The tension-tension fatigue cycles are tabulated by lot and also plotted to show an S-N curve. Appendix I includes the results of the tests on all parts heat treated to 160,000 psi and Appendix II includes those for the 220,000 psi parts.

To simplify the data, combined S-N curves plotted as tensile stress area, which is mean area, versus logarithmic mean life are given as follows:

SECTION VII

DISCUSSION OF RESULTS

A. STUD DESIGN:

To evaluate the properties of unengaged threads, it was necessary to develop a specimen with threads which were not loaded through female threads. As outlined in the section on Test Pieces, various designs were tried, to determine if fracture could be induced near the center of the test thread. This could not be achieved on the specimens roll threaded after heat treatment; therefore, a design was selected which induced fatigue fracture in the last full thread before the termination. Thus the effect of the thread runout was reduced to the lowest possible degree. However, in the larger sizes, 3/4 and 1 inch diameters, it was necessary to cold work by shot-peening the radius blending the test section to the loading threads. A P-33 shot was used at an intensity of .014 C2. Without this, fatigue fracture occurred outside the test area. Figures 77 and 78.

The initial one-inch test specimens were produced with two inch cut threads on the ends. Fatigue failure occurred at the junction of this thread and the radius as shown in Figure 79. Fatigue failures were produced in the 1-14 thread by using a 1 3/4-12 rolled thread on the ends.

The test specimens with cut and ground threads were made to the same configuration as the roll threaded parts. In this case, fatigue failure occurred near the center of the test cut and ground threads, Figure 80.

B. EFFECT OF ENGAGING THREADS ON FATIGUE LIFE:

The fatigue strength of unengaged threads is 1 1/4 to 2 1/2 times greater than that of the engaged threads. This comparison is based on the maximum stress which would produce a fatigue life greater than 8,000,000 cycles. The difference between the average fatigue life of all studs and bolts with MIL-B-7838 threads is shown in Chart I. Table VI lists the fatigue strength at 8,000,000 cycles for each lot of bolts and studs with MIL-B-7838 threads.

TABLE VI

Fatigue Strength at 8,000,000 Cycles
Stress Calculated on Tensile Stress Area

MIL-S-6049 Material - 160,000 psi minimum
MIL-B-7838 Thread Form

Test Thread Diameter	Stress to Produce Fatigue Life of More Than 8,000,000 Cycles	
	Stud	Bolt
1/4	95,000	40,000
3/8	80,000	40,000
1/2	100,000	40,000
3/4	100,000	40,000
1	100,000	50,000

MIL-S-7108 Material - 220,000 psi minimum
MIL-B-7838 Thread Form

Test Thread Diameter	Stud	Bolt
1/4	120,000	80,000
3/8	100,000	60,000
1/2	120,000	65,000
3/4	120,000	55,000
1	135,000	80,000

In the case of 160,000 psi heat treatment, the stud fatigue strength was 2 to 2 1/2 times greater than the bolt. For the 220,000 psi strength level with the MIL-B-7838 thread roots the stud strength was 1 1/2 to 2 times greater. The studs with the high radius thread root made from Hy Tuf at 220,000 psi had a fatigue strength only 1 1/4 to 1 1/2 times greater than the bolt with the same thread form. Since the difference between the fatigue strength of the stud and bolt is less with the high radius thread than the MIL-B-7838 threads, the stress concentration in the threads must be less with the high radius thread than the MIL-B-7838 thread. This indicates that bolts with larger thread root radii are affected less by the stress concentration due to the nut. This is demonstrated by the bolt fatigue strength being nearer the unengaged fatigue strength.

C. EFFECT OF MATERIAL ON FATIGUE STRENGTH:

The fatigue strength of the studs fabricated from VascoJet 1000 is 10% greater than similar parts made from MIL-S-7108 material, Chart 2. The fatigue strength of the VascoJet 1000 bolts is 18% greater than those made from MIL-S-7108, Chart 3.

The fatigue strength of the MIL-S-8503 material is slightly lower than the Hy Tuf in both stud and bolt tests, Chart 4.

D. EFFECT OF MATERIAL STRENGTH ON FATIGUE STRENGTH OF THREADS:

By increasing the strength of the material from 160,000 psi to 220,000 psi (1.4 times) an increase of 1.2 to 1.45 was obtained in the fatigue strength of the studs. MIL-S-8503 had a 1.2 increase in fatigue life, MIL-S-7108 a 1.3 increase, while VascoJet 1000 showed a 1.45 increase.

The increase in the fatigue strength of the bolts due to the increase of 1.4 in tensile strength was between 1.4 and 2.8. The bolts made from MIL-S-7108 and MIL-S-8503 were about the same at 1.4 to 2. The one lot of VascoJet studs with the high radius threads increased 2.8 times. This is an increase of twice the increase in tensile strength.

The increase in the bolt fatigue life is equal to or greater than the increase in tensile strength. However, the stud fatigue life increased slightly less than the tensile strength. This may be due to the stress concentration in the thread termination which was not completely eliminated by the design of the stud.

E. EFFECT OF THREAD ROOT RADIUS ON FATIGUE STRENGTH:

The comparison of the effect of MIL-B-7838 and high radius root radii on the fatigue life is based on parts heat treated to 220,000 psi. These were the only parts made with both thread forms.

At the high stress levels the fatigue strength of the unengaged high radius thread is superior to the MIL-B-7838 thread. This is shown in Charts 5 and 6. At a life of more than 8,000,000 cycles, there was little or no difference between the thread forms.

The fatigue strength of the bolts with the high radius thread form was at least 1.5 times greater than the parts with the MIL-B-7838 thread. This comparison is shown in Chart 7 for the 1/2 inch diameter bolts and Chart 8 for the 3/4 inch diameter bolts.

Since the bolt tests showed a definite superiority of the high radius over the MIL-B-7838 thread, it is probable that the same difference was not found in the studs because the effect of the thread termination was greater than that of the thread form. The stress concentration due to the thread engagement with the bolt was sufficiently large enough to cause fatigue failures to occur in the area of the nut bearing face rather than at the thread termination.

F. EFFECT OF NUT DESIGN ON FATIGUE STRENGTH OF BOLTS:

Charts 9 and 10 show comparative S-N curves developed with locknuts having metallic threads and those having a non-metallic element in the locking section. In both tests the nuts with all-metal threads produced superior fatigue life in the mating part. It appears that as the size increases the difference between the two designs becomes greater. The superiority of the all-metal nut can be attributed to less stress concentration in the bolt resulting from better load distribution in the nut. With more metallic threads the load per thread is less; thus the stress concentration is reduced.

G. EFFECT OF PLATING ON THE FATIGUE STRENGTH OF UNENGAGED THREADS:

Plating decreases the fatigue strength of threaded parts. A reduction of 6% to 11% was found on the studs heat treated to 160,000 psi. The cadmium plating of the 220,000 psi studs reduced the fatigue strength 9% to 16%. A reduction of 10% was found in the one lot of 220,000 psi studs with the high radius thread.

As shown in Table VII, size had no effect on the fatigue life reduction due to plating.

TABLE VII

Effect of Plating on the Fatigue Strength of Unengaged Threads
Fatigue Stress to Produce a Life of 100,000 Cycles

Size	Strength	Thread Form	Stress Non-Plated	Plated	% Reduction
1/4	160,000	MIL-B	127,000	120,000	5.51
3/8	160,000	MIL-B	117,000	104,000	11.1
3/4	160,000	MIL-B	128,000	120,000	6.25
1/4	220,000	MIL-B	150,000	122,000	18.7
3/8	220,000	MIL-B	134,000	122,000	8.96
3/4	220,000	MIL-B	157,000	135,000	14.0
3/4	220,000	High Radius	158,000	142,000	10.13

H. EFFECT OF CUT THREADS ON FATIGUE:

The fatigue strength of the unengaged cut threads is 34% to 60% of the rolled MIL-B-7838 thread. The fatigue strength at a life of 100,000 cycles of the cut threads on parts heat treated to 160,000 psi was 60% of that obtained with rolled threads. Under similar conditions the fatigue strength of the cut threads on studs heat treated to 220,000 psi was 34% of the rolled threads, Chart 11.

Table VIII shows the comparative fatigue strength of unengaged cut and rolled threads at a life of 100,000 cycles.

TABLE VIII

Rolled Thread after Heat Treatment vs Cut Thread
Fatigue Strength to Produce Fracture at 100,000 Cycles
All parts were 3/4-16 unengaged threads

Tensile Strength - psi minimum	Fatigue Strength - psi Rolled	Cut
160,000	126,000	75,000
220,000	160,000	55,000

I. EFFECT OF GROUND THREADS ON FATIGUE:

The fatigue strength of ground threads is less than rolled threads but greater than cut threads.

The fatigue strength at 100,000 cycles of the ground threads on parts heat treated to 160,000 psi is 68% of that obtained by rolled threads. On studs heat treated to 220,000 psi the fatigue strength of the unengaged ground thread was 56% of the rolled thread, Chart 12.

Part of the difference between the ground and cut threads can be due to the thread forms. The cut thread had a flat root where as the ground thread had a radius conforming to MIL-B-7838.

Table IX shows the comparative fatigue strength of unengaged ground and rolled threads at a life of 100,000 cycles.

TABLE IX

Rolled Thread after Heat Treatment vs Ground Thread
Fatigue Strength to Produce Fracture at 100,000 Cycles
All parts were 3/4-16 unengaged threads

Tensile Strength - psi minimum	Fatigue Strength - psi	
	Rolled	Ground
160,000	126,000	85,000
220,000	160,000	90,000

SECTION VIII

CONCLUSIONS

The fatigue strength of unengaged threads is about 1 1/2 times that of engaged threads.

With the proper selection of the material the fatigue strength of rolled threads increases in direct proportion to the tensile strength.

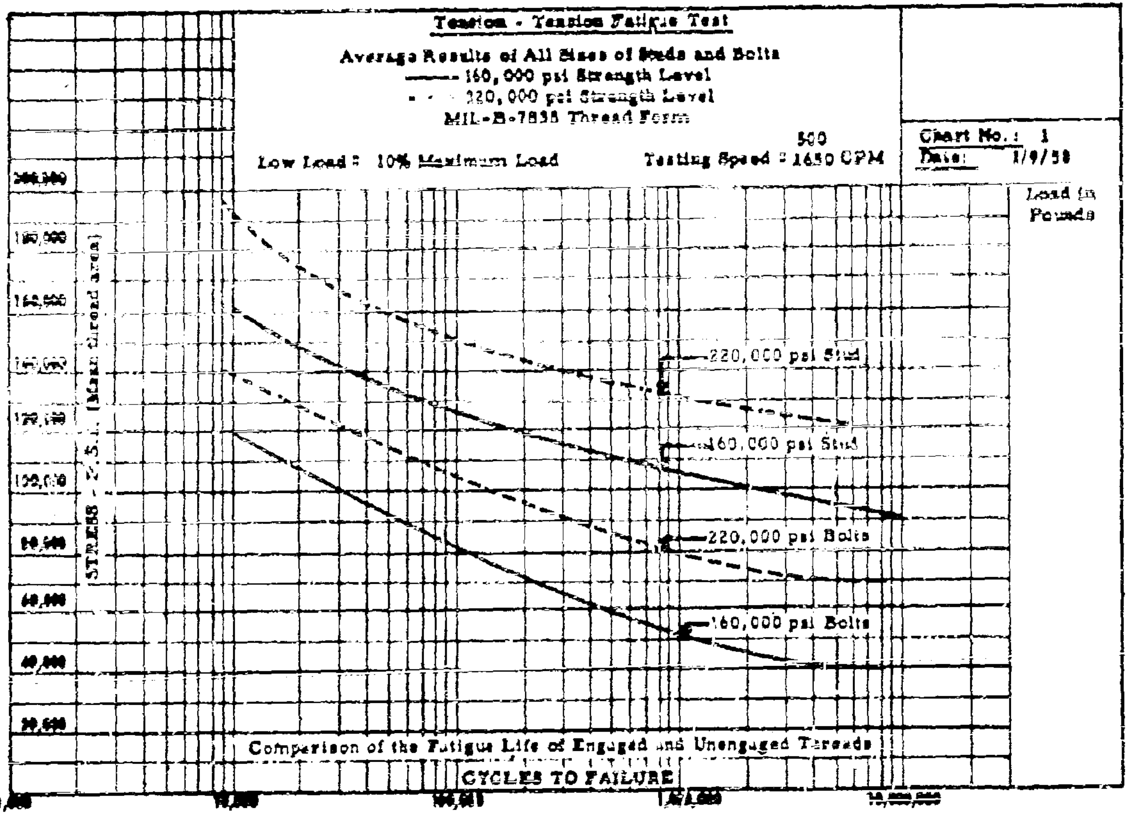
By increasing the thread root radius, the fatigue strength of threads can be increased.

Nut design affects the fatigue strength of fasteners. Generally as the thread engagement decreases the strength decreases.

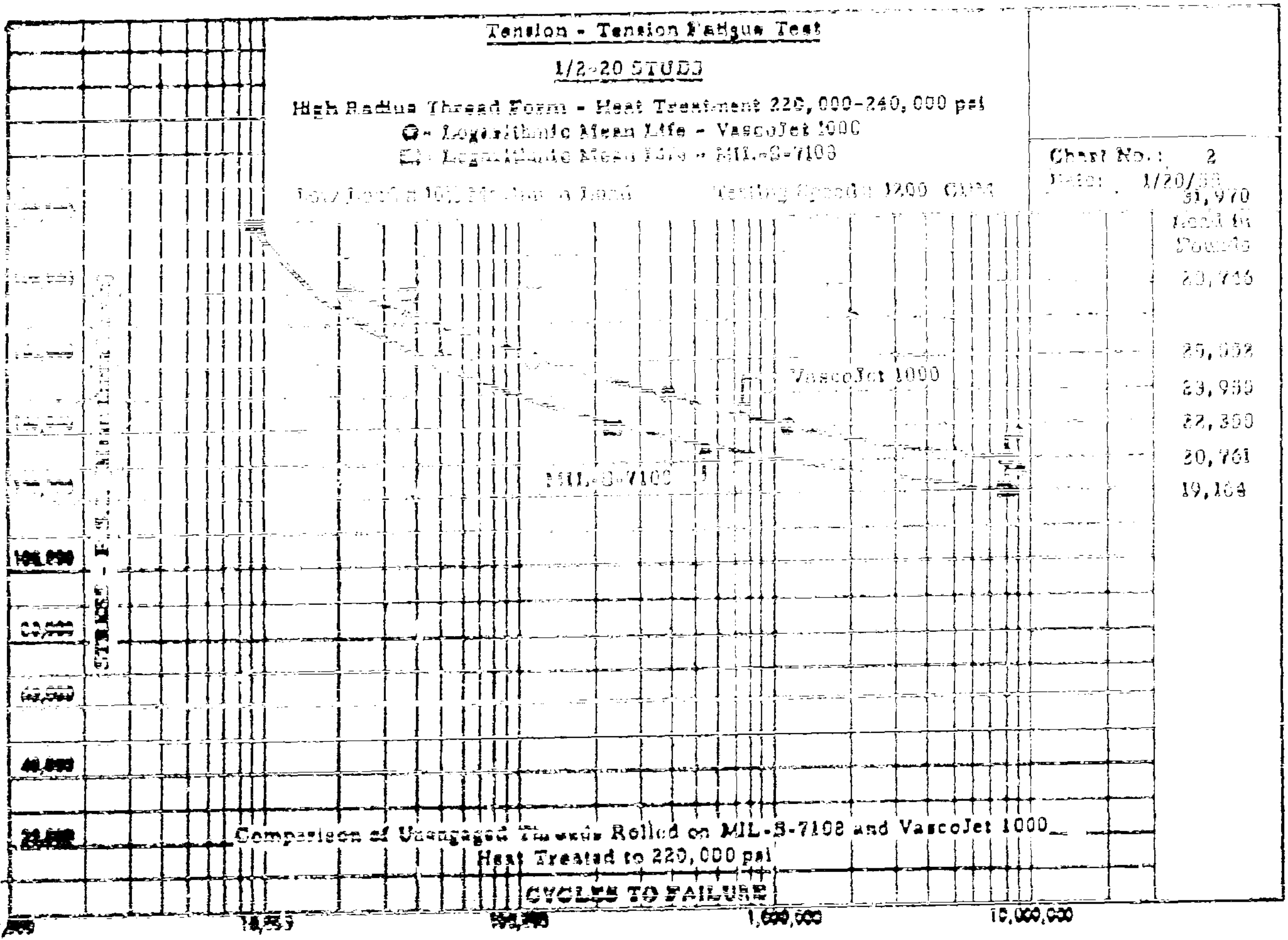
Cadmium plating reduces the fatigue strength of threads an average of 15%.

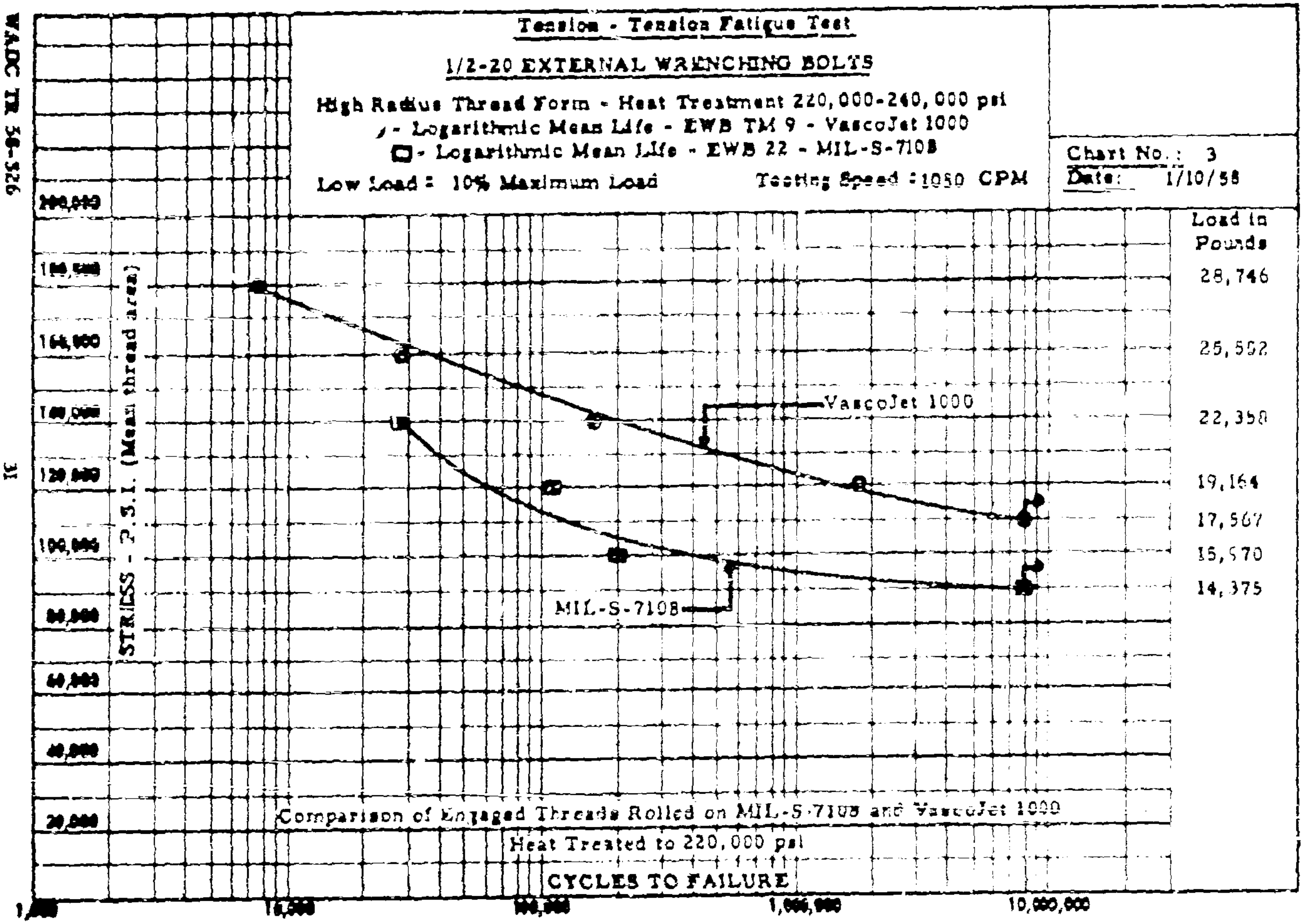
The fatigue strength of unengaged cut threads is 34% of the rolled threads on parts heat treated to 160,000 psi and 60% of rolled threads on 220,000 psi parts.

The fatigue strength of unengaged ground threads is greater than that of cut threads but less than rolled threads. The fatigue strength of the ground thread is 68% of the thread rolled on 160,000 psi material and 56% on 220,000 psi material.

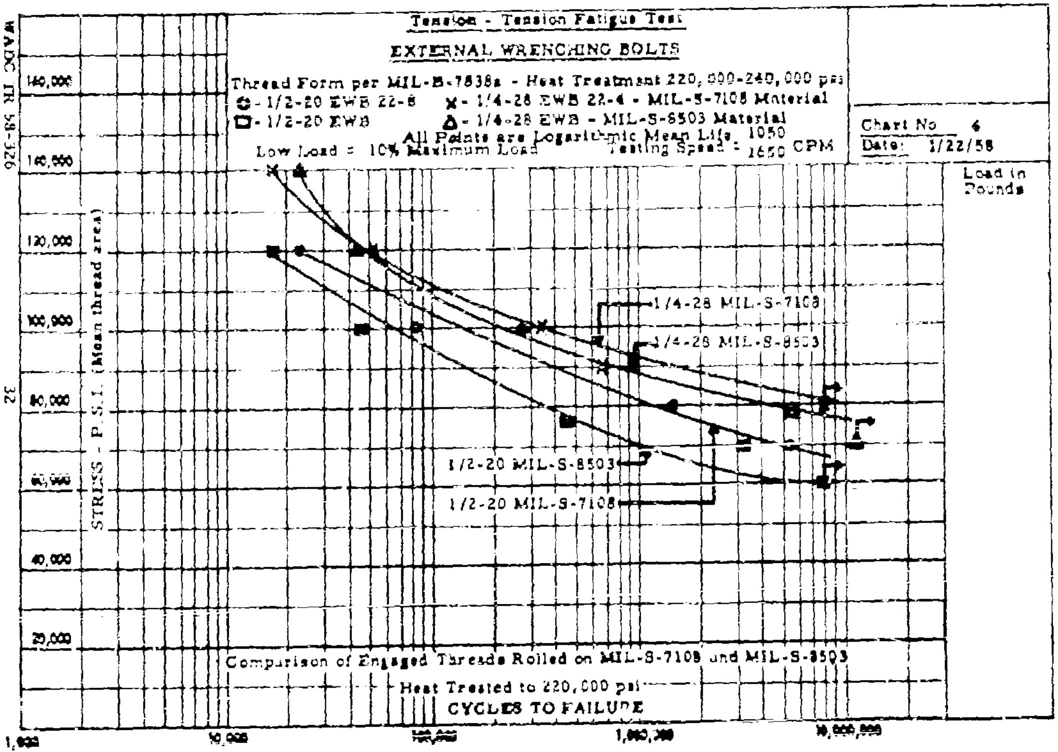


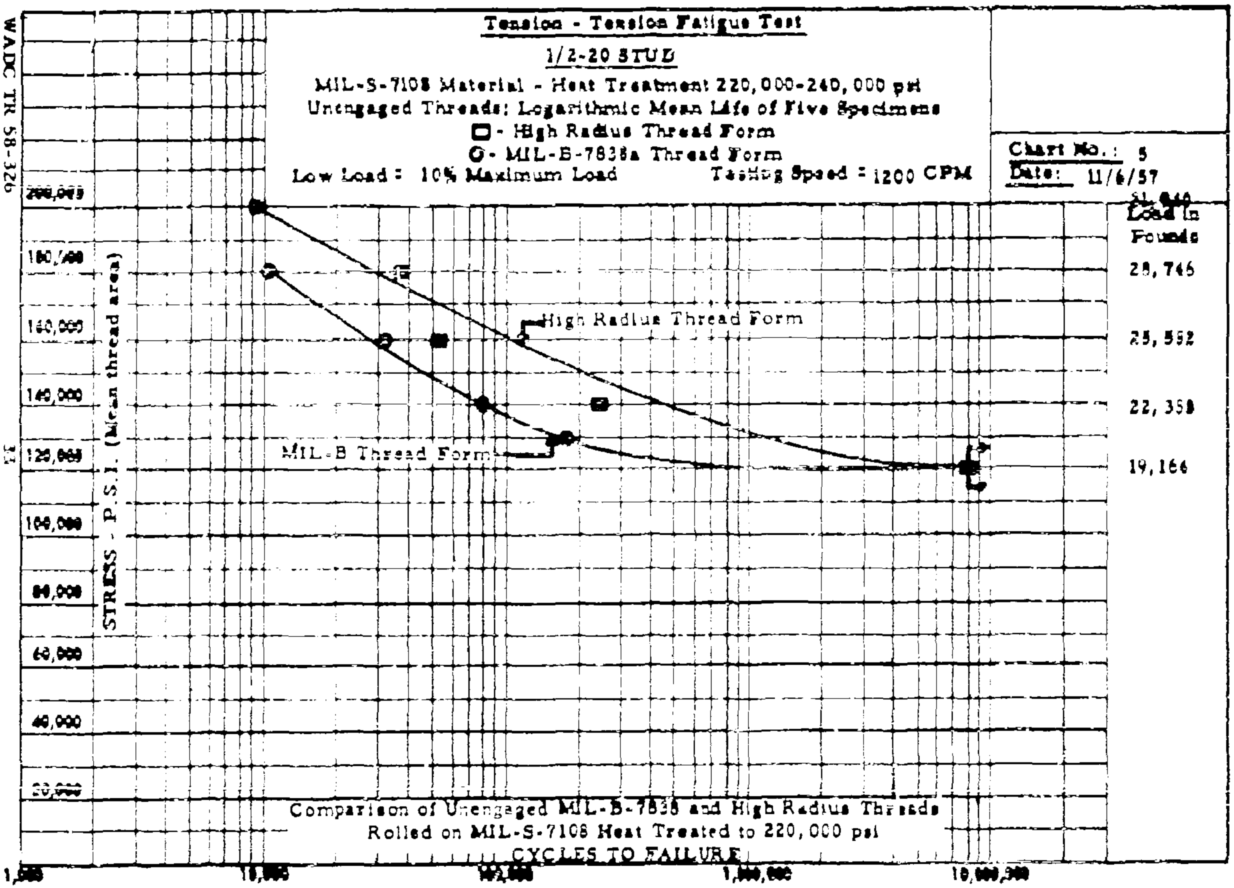
Tension - Tension Fatigue Test
Average Results of All Sizes of Studs and Bolts
160,000 psi Strength Level
220,000 psi Strength Level
MIL-B-7838 Thread Form
Low Load = 10% Maximum Load
500
Testing Speed = 1650 CPM
Chart No.: 1
Date: 1/9/58
Load in Pounds
STRESS - P.S.I. (Major thread area)
220,000 psi Stud
160,000 psi Stud
220,000 psi Bolts
160,000 psi Bolts
Comparison of the Fatigue Life of Engaged and Unengaged Threads
CYCLES TO FAILURE

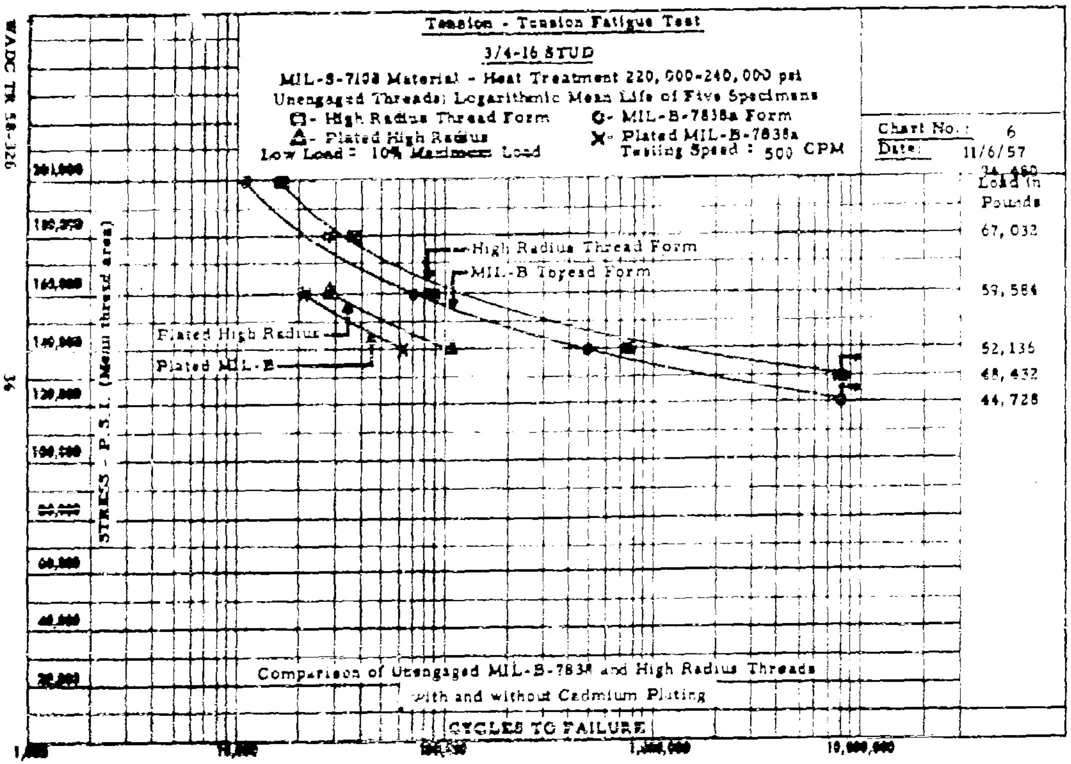

Tension - Tension Fatigue Test
1/2-20 STUDS
High Radius Thread Form - Heat Treatment 220,000-240,000 psi
○ - Logarithmic Mean Life - VascoJet 1000
□ - Logarithmic Mean Life - MIL-S-7108
Testing Speed: 1200 CPM
Chart No.: 2
VascoJet 1000
MIL-S-7108
Load in Pounds
31,970
29,746
25,058
23,950
22,300
20,761
19,164
STRESS - P.S.I.
100,000
80,000
60,000
40,000
20,000
Comparison of Unengaged Threads Rolled on MIL-S-7108 and VascoJet 1000
Heat Treated to 220,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

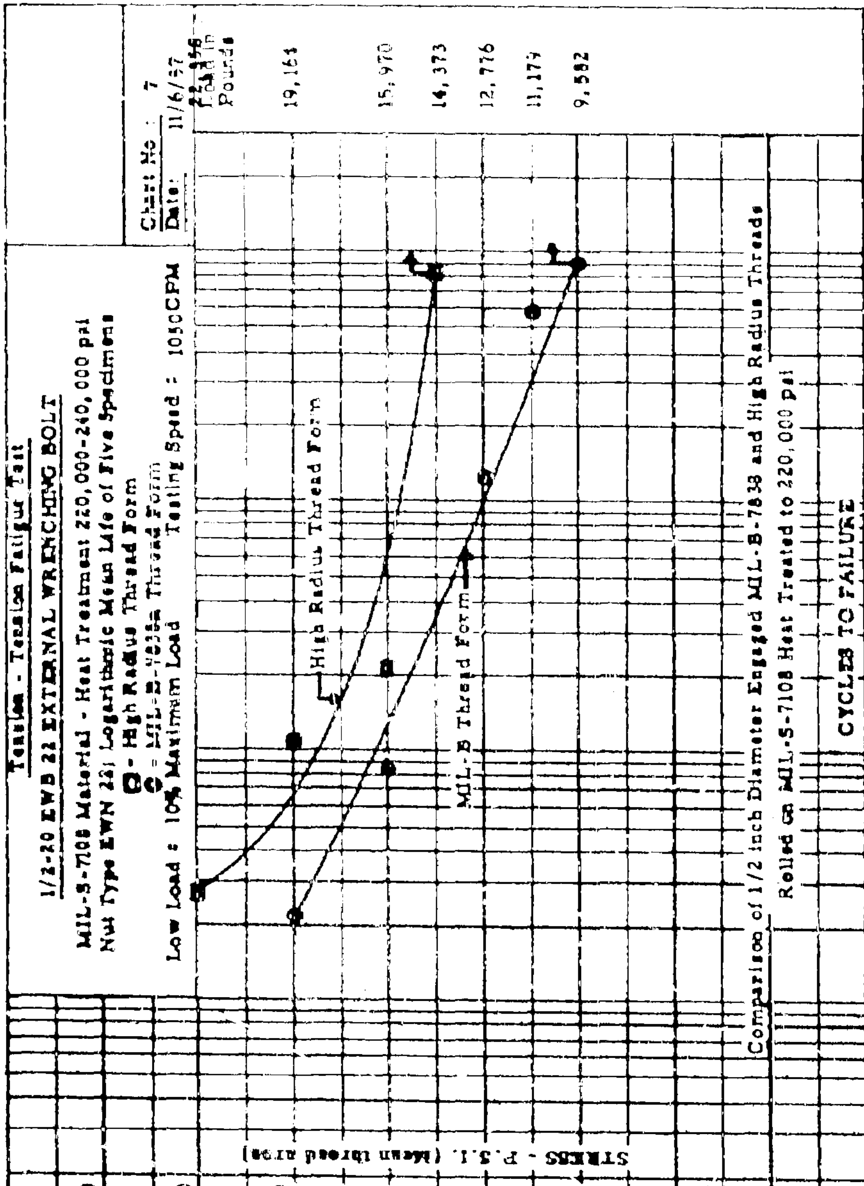


Tension - Tension Fatigue Test
1/2-20 EXTERNAL WRENCHING BOLTS
High Radius Thread Form - Heat Treatment 220,000-240,000 psi
- Logarithmic Mean Life - EWB TM 9 - VascoJet 1000
- Logarithmic Mean Life - EWB 22 - MIL-S-7108
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No.: 3
Date: 1/10/58
Load in Pounds
28,746
25,552
22,358
19,164
17,567
15,970
14,375
VascoJet 1000
MIL-S-7108
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Comparison of Engaged Threads Rolled on MIL-S-7108 and VascoJet 1000
Heat Treated to 220,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

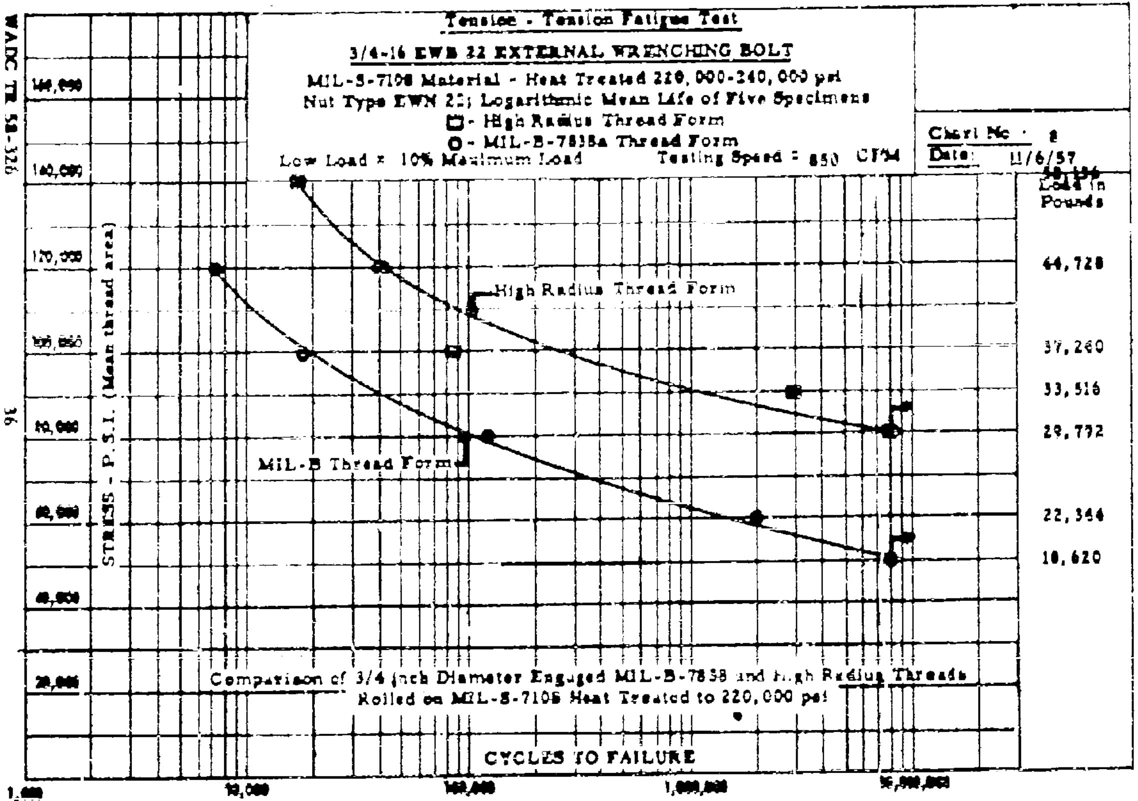

Tension - Tension Fatigue Test
EXTERNAL WRENCHING BOLTS
Thread Form per MIL-B-7838a - Heat Treatment 220,000-240,000 psi
○ - 1/2-20 EWB 22-8
X - 1/4-28 EWB 22-4 - MIL-S-7108 Material
□ - 1/2-20 EWB
Δ - 1/4-28 EWB - MIL-S-8503 Material
All Points are Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed - 1050 1650 CPM
Chart No 4
Date: 1/22/58
Load in Pounds
STRESS - P.S.I. (Mean thread area)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
1/4-28 MIL-S-7108
1/4-28 MIL-S-8503
1/2-20 MIL-S-8503
1/2-20 MIL-S-7108
Comparison of Engaged Threads Rolled on MIL-S-7108 and MIL-S-8503
Heat Treated to 220,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

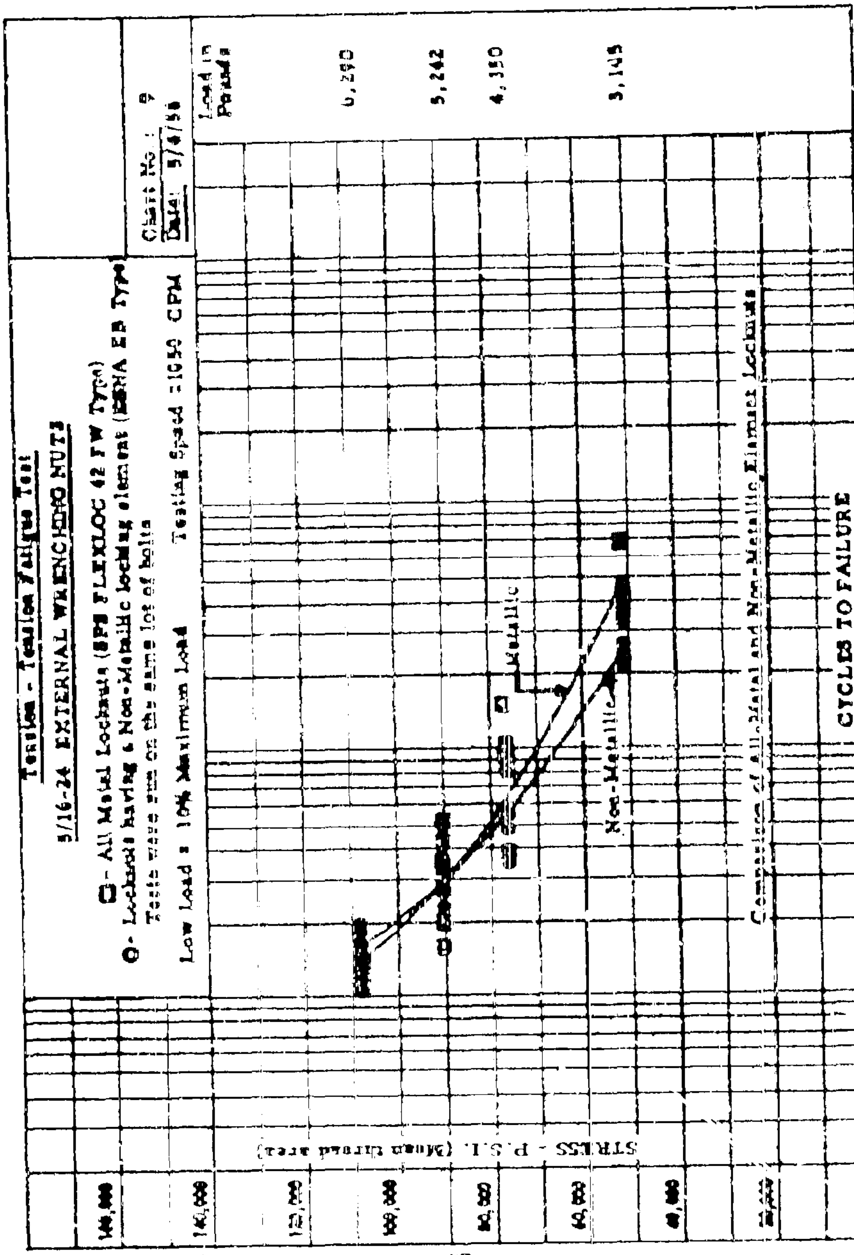

Tension - Tension Fatigue Test
1/2-20 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 psi
Unengaged Threads: Logarithmic Mean Life of Five Specimens
☐ - High Radius Thread Form
O - MIL-B-7838a Thread Form
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No.: 5
Date: 11/6/57
Load in Pounds
28,746
25,552
22,358
19,164
High Radius Thread Form
MIL-B Thread Form
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Comparison of Unengaged MIL-B-7838 and High Radius Threads
Rolled on MIL-S-7108 Heat Treated to 220,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 psi
Unengaged Threads; Logarithmic Mean Life of Five Specimens
□ - High Radius Thread Form
○ - MIL-B-7838a Form
△ - Plated High Radius
X - Plated MIL-B-7838a
Low Load = 10% Maximum Load
Testing Speed : 500 CPM
Chart No.: 6
Date: 11/6/57
Load in Pounds
67,032
59,584
52,136
48,432
44,728
High Radius Thread Form
MIL-B Thread Form
Plated High Radius
Plated MIL-B
STRESS - P.S.I. (Mean thread area)
180,000
160,000
140,000
120,000
100,000
60,000
40,000
20,000
Comparison of Unengaged MIL-B-7838 and High Radius Threads
with and without Cadmium Plating
CYCLES TO FAILURE
1,000
10,000
1,000,000
10,000,000

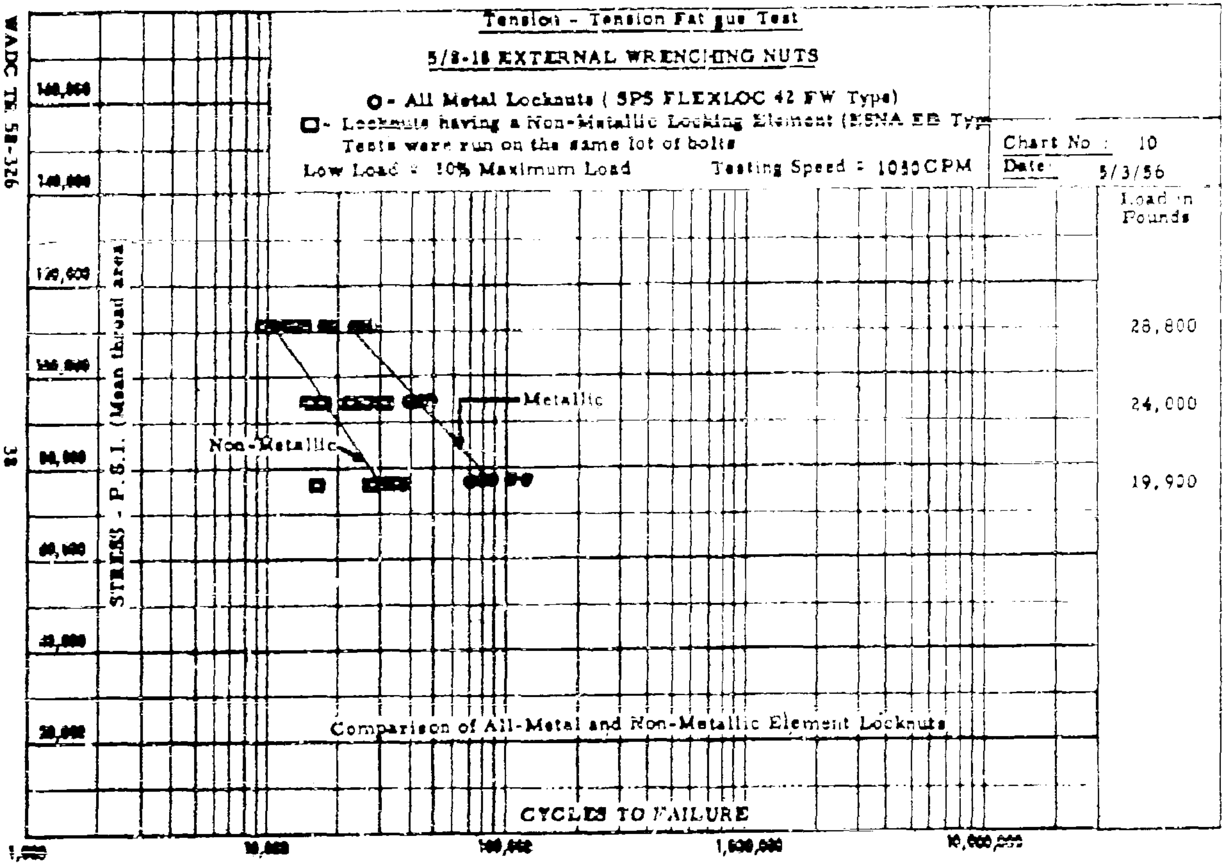


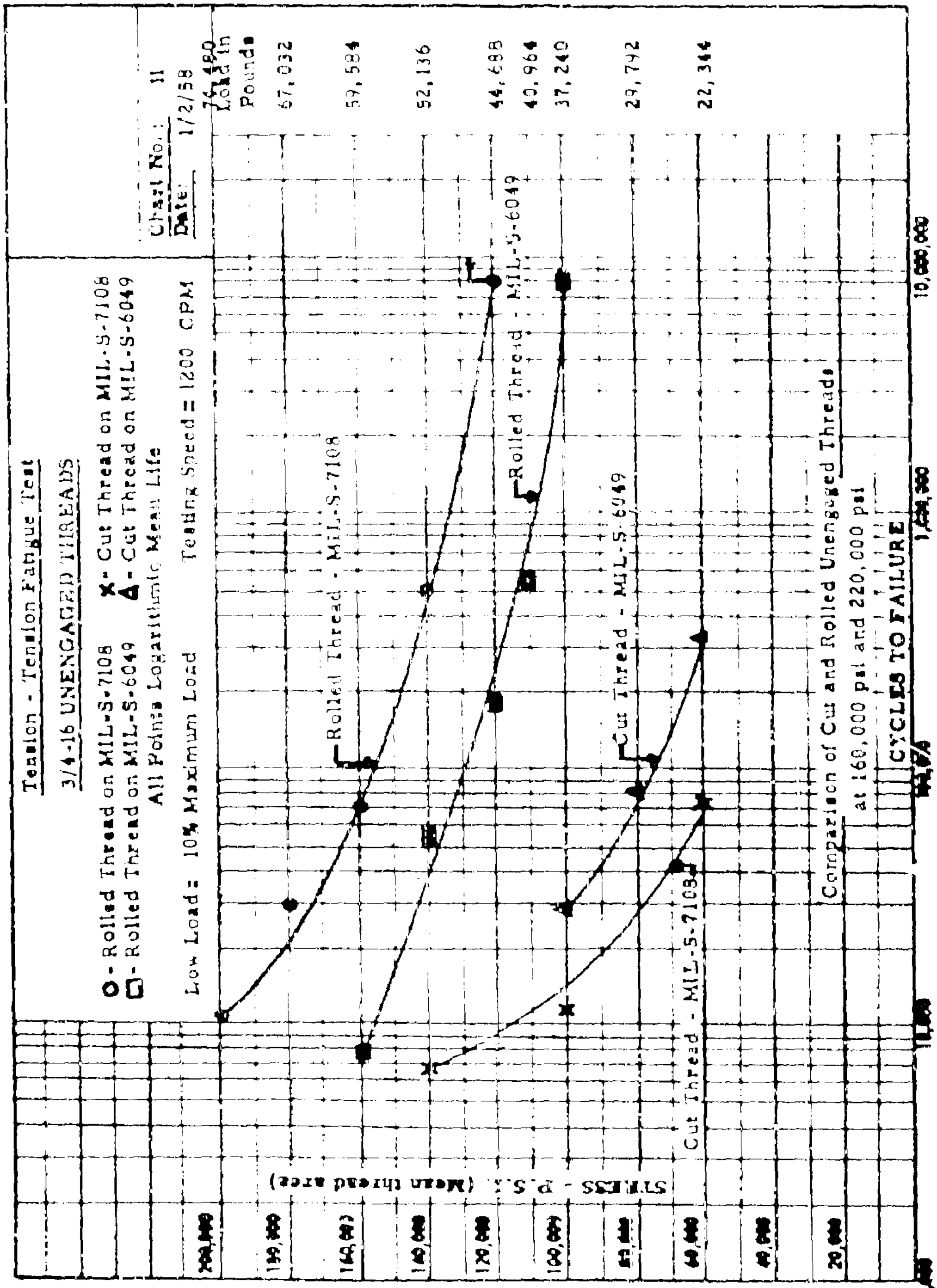
Tension - Tension Fatigue Test
1/2-20 EWB 22 EXTERNAL WRENCHING BOLT
MIL-S-7108 Material - Heat Treatment 220,000-240,000 psi
Nut Type EWN 22: Logarithmic Mean Life of Five Specimens
- High Radius Thread Form
= MIL-B-7838 Thread Form
Low Load = 10% Maximum Load
Testing Speed = 1050CPM
Chart No: 7
Date: 11/6/57
Load in Pounds
19,163
15,970
14,373
12,776
11,179
9,582
High Radius Thread Form
MIL-B Thread Form
STRESS - P.S.I. (Mean thread area)
Comparison of 1/2 inch Diameter Engaged MIL-B-7838 and High Radius Threads
Rolled on MIL-S-7108 Heat Treated to 220,000 psi
CYCLES TO FAILURE

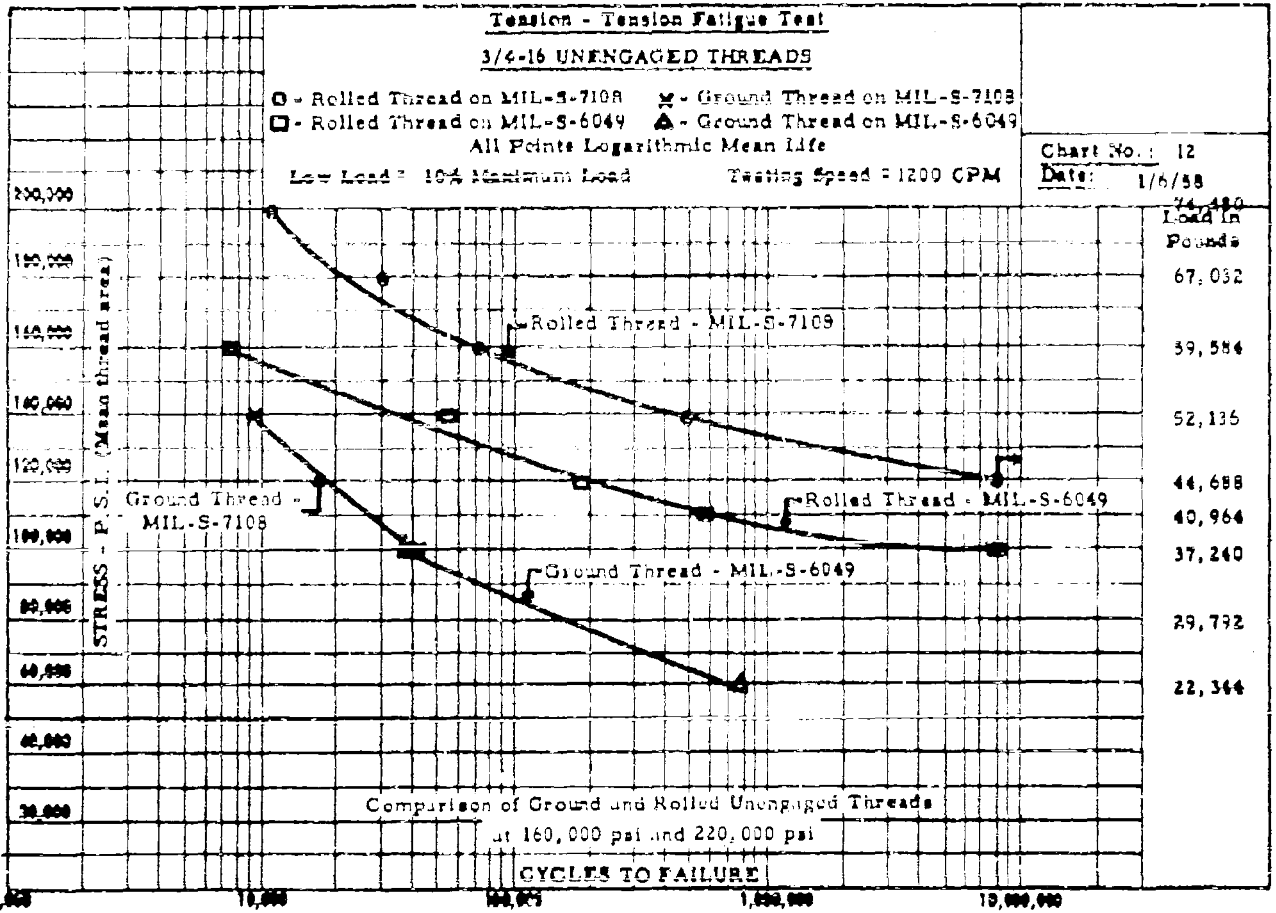

Tension - Tension Fatigue Test
3/4-16 EWB 22 EXTERNAL WRENCHING BOLT
MIL-S-7108 Material - Heat Treated 220,000-240,000 psi
Nut Type EWN 22; Logarithmic Mean Life of Five Specimens
□ - High Radius Thread Form
O - MIL-B-7838a Thread Form
Low Load = 10% Maximum Load
Testing Speed = 850 CPM
Chart No. 8
Date: 11/6/57
Load in Pounds
44,728
37,260
33,516
29,772
22,344
18,620
High Radius Thread Form
MIL-B Thread Form
STRESS - P.S.I. (Mean thread area)
Comparison of 3/4 inch Diameter Engaged MIL-B-7838 and High Radius Threads
Rolled on MIL-S-7108 Heat Treated to 220,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

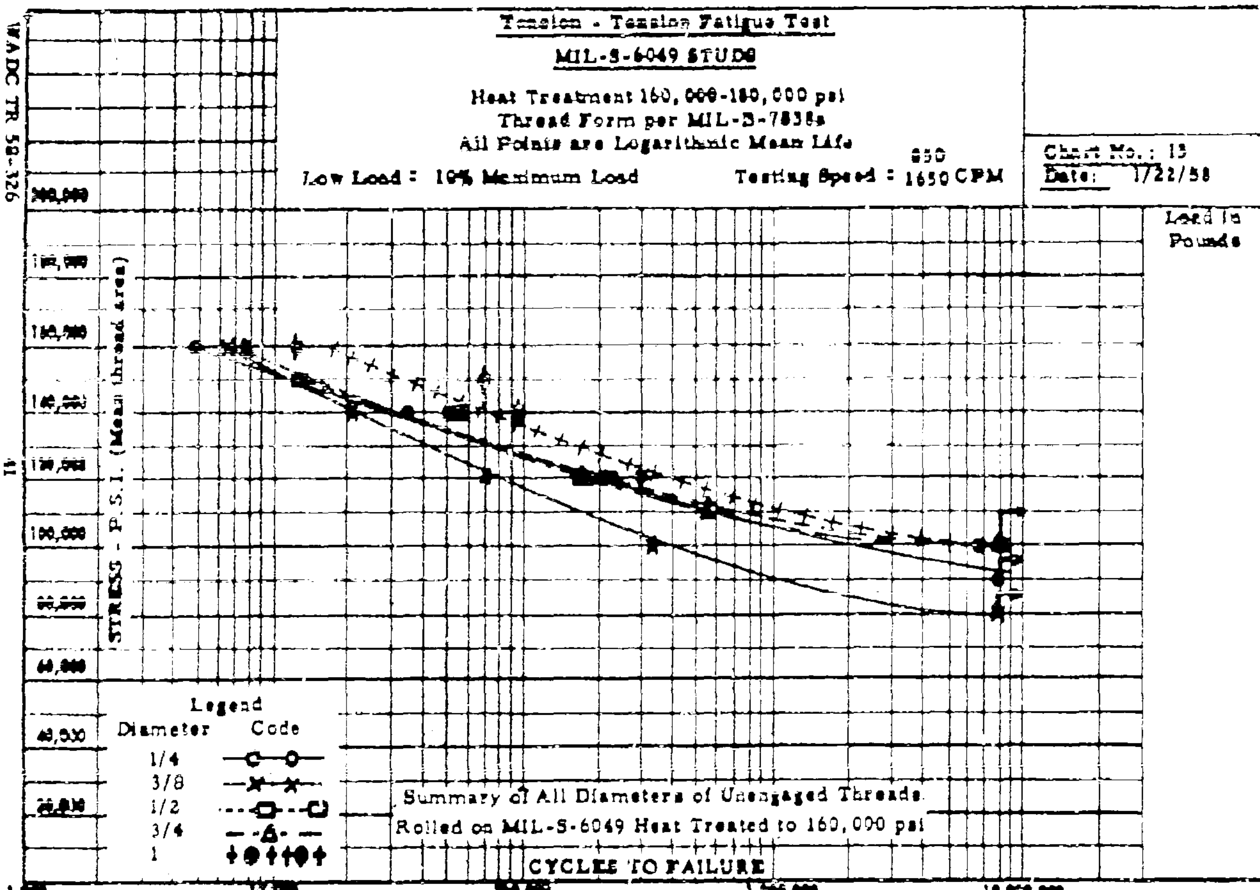


Tension - Tension Fatigue Test
5/16-24 EXTERNAL WRENCHING NUTS
□ - All Metal Locknuts (SPS FLEXLOC 42 FW Type)
○ - Locknuts having a Non-Metallic locking element (ESNA EB Type)
Tests were run on the same lot of bolts
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Load in Pounds
6,290
5,242
4,350
3,145
Metallic
Non-Metallic
Comparison of All-Metal and Non-Metallic Element Locknuts
CYCLES TO FAILURE
STRESS - P.S.I. (Mean thread area)
140,000
120,000
100,000
80,000
60,000
1,000
10,000
100,000
1,000,000
10,000,000

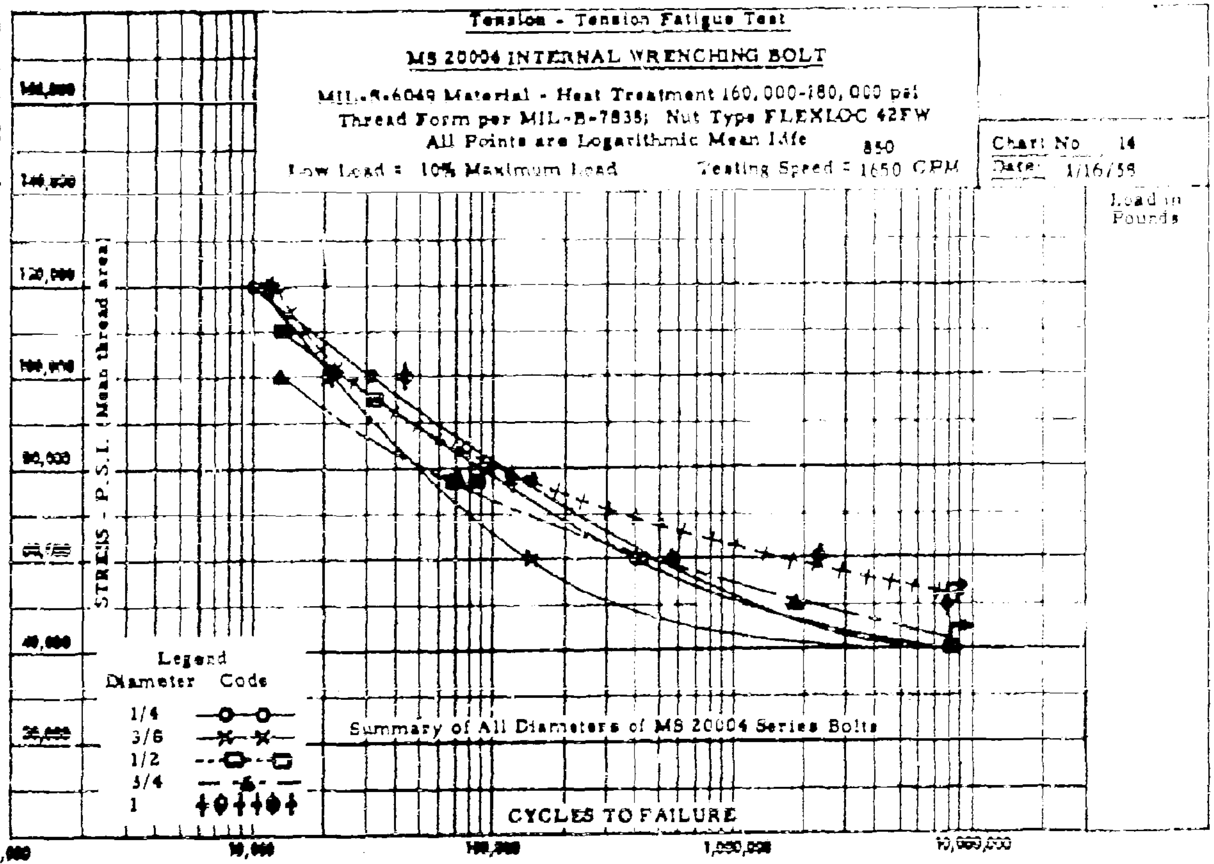

Tension - Tension Fatigue Test
5/8-18 EXTERNAL WRENCHING NUTS
O - All Metal Locknuts (SPS FLEXLOC 42 FW Type)
□ - Locknuts having a Non-Metallic Locking Element (ESNA EB Type
Tests were run on the same lot of bolts
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No : 10
Date: 5/3/56
Load in Pounds
28,800
24,000
19,900
Metallic
Non-Metallic
STRESS - P.S.I. (Mean thread area)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Comparison of All-Metal and Non-Metallic Element Locknuts
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

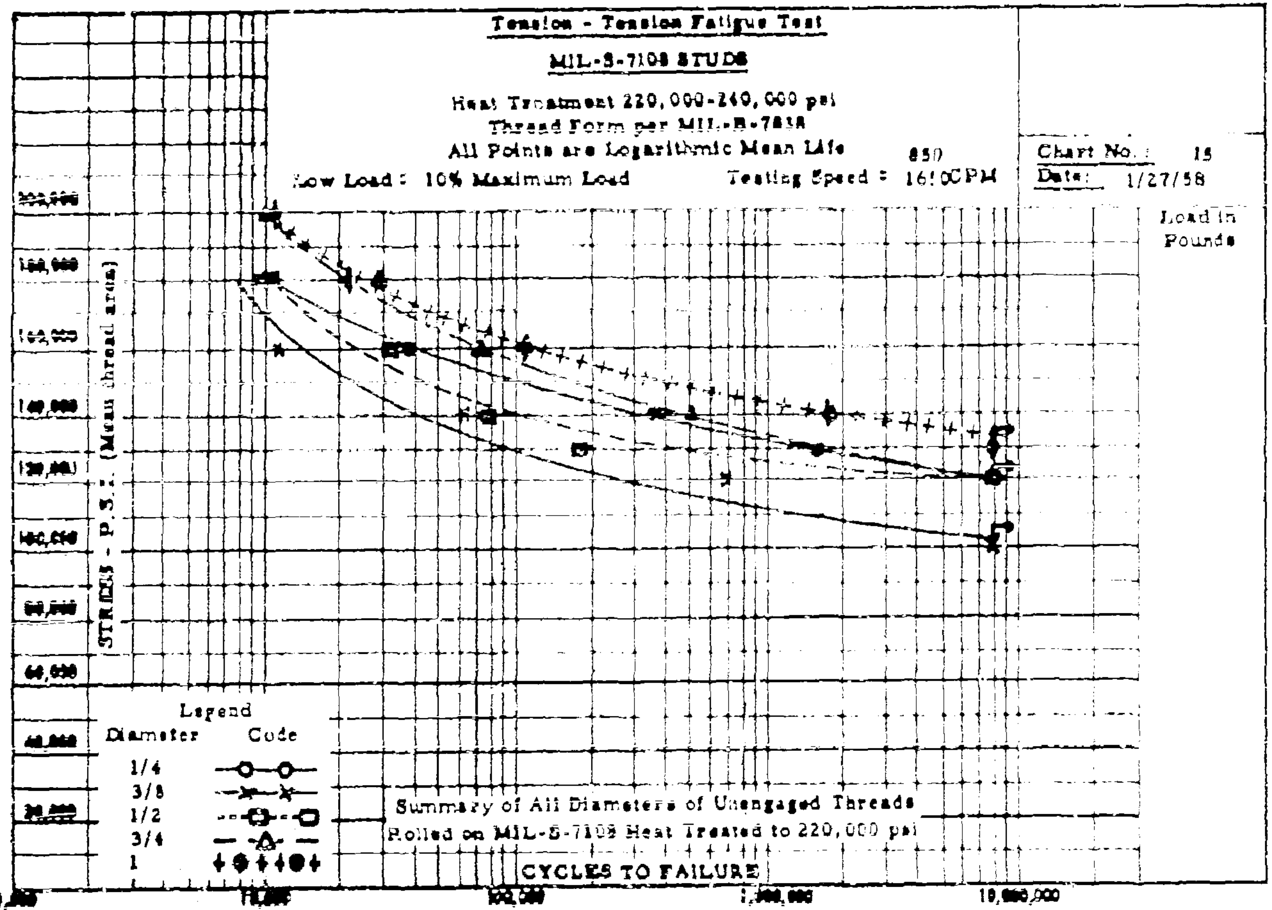

Tension - Tension Fatigue Test
3/4-16 UNENGAGED THREADS
O - Rolled Thread on MIL-S-7108
□ - Rolled Thread on MIL-S-6049
X - Cut Thread on MIL-S-7108
Δ - Cut Thread on MIL-S-6049
All Points Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No.: 11
Date: 1/2/58
Load in Pounds
74,480
67,032
59,584
52,136
44,688
40,964
37,240
29,792
22,344
Rolled Thread - MIL-S-7108
Rolled Thread - MIL-S-6049
Cut Thread - MIL-S-6049
Cut Thread - MIL-S-7108
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Comparison of Cut and Rolled Unengaged Threads
at 160,000 psi and 220,000 psi
CYCLES TO FAILURE
1,000,000
10,000,000


Tension - Tension Fatigue Test
3/4-16 UNENGAGED THREADS
O - Rolled Thread on MIL-S-7108
□ - Rolled Thread on MIL-S-6049
Ground Thread on MIL-S-7108
△ - Ground Thread on MIL-S-6049
All Points Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No.: 12
Date: 1/6/58
Load in Pounds
74,480
67,032
59,584
52,136
44,688
40,964
37,240
29,792
22,344
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
30,000
STRESS - P.S.I. (Mean thread area)
Rolled Thread - MIL-S-7108
Rolled Thread - MIL-S-6049
Ground Thread - MIL-S-7108
Ground Thread - MIL-S-6049
Comparison of Ground and Rolled Unengaged Threads
at 160,000 psi and 220,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

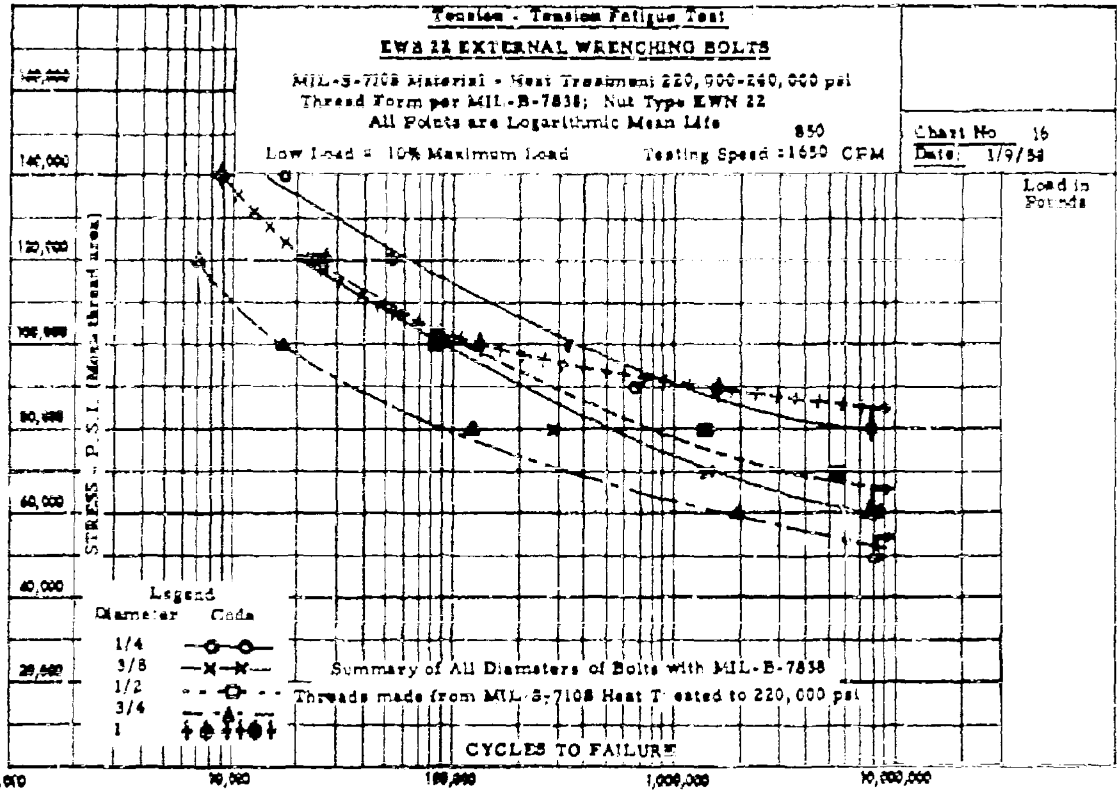


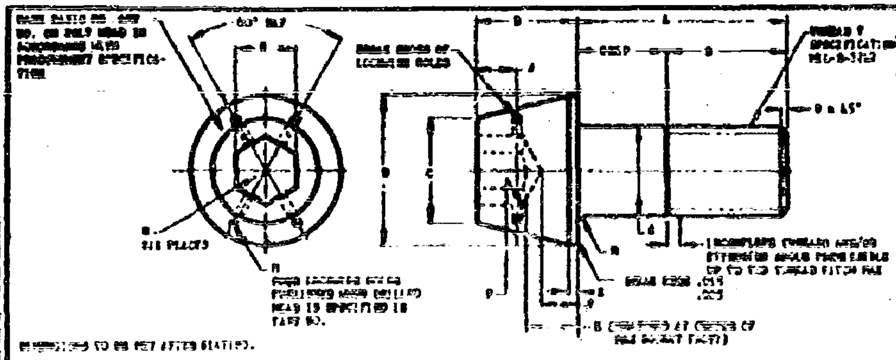
Tension - Tension Fatigue Test
MIL-S-6049 STUDS
Heat Treatment 160,000-180,000 psi
Thread Form per MIL-S-7838a
All Points are Logarithmic Mean Life
Low Load : 10% Maximum Load
Testing Speed : 850 1650 CPM
Chart No.: 15
Date: 1/22/58
Load in Pounds
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
Legend
Diameter Code
1/4
3/8
1/2
3/4
1
Summary of All Diameters of Unengaged Threads
Rolled on MIL-S-6049 Heat Treated to 160,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000


Tension - Tension Fatigue Test
MS 20004 INTERNAL WRENCHING BOLT
MIL-S-6049 Material - Heat Treatment 160,000-180,000 psi
Thread Form per MIL-B-7838; Nut Type FLEXLOC 42FW
All Points are Logarithmic Mean Life
Low Load = 10% Maximum Load
850
Testing Speed = 1650 CPM
Chart No 14
Date: 1/16/58
Load in Pounds
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
STRESS - P.S.I. (Mean thread area)
Legend
Diameter Code
1/4
3/8
1/2
3/4
1
Summary of All Diameters of MS 20004 Series Bolts
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000



Tension - Tension Fatigue Test
MIL-S-7108 STUDS
Heat Treatment 220,000-240,000 psi
Thread Form per MIL-B-7838
All Points are Logarithmic Mean Life
Low Load : 10% Maximum Load
Testing Speed = 1610CPM
850
Chart No.: 15
Date: 1/27/58
Load in Pounds
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Legend
Diameter Code
1/4
3/8
1/2
3/4
1
Summary of All Diameters of Unengaged Threads
Rolled on MIL-S-7108 Heat Treated to 220,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000


Tension - Tension Fatigue Test
EWB 22 EXTERNAL WRENCHING BOLTS
MIL-S-7108 Material - Heat Treatment 220,000-240,000 psi
Thread Form per MIL-B-7838; Nut Type EWN 22
All Points are Logarithmic Mean Life
Low Load = 10% Maximum Load
850
Testing Speed =1650 CPM
Chart No 16
Date: 1/9/58
Load in Pounds
140,000
120,000
100,000
80,000
60,000
40,000
20,000
STRESS - P.S.I. (Mean thread area)
Legend
Diameter Code
1/4
3/8
1/2
3/4
1
Summary of All Diameters of Bolts with MIL-B-7838
Threads made from MIL-S-7108 Heat Treated to 220,000 psi
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000



Basic MS part no.	Thread T	A	B	C	D	E	F	H	J	K	L	M	P	R	S	U	Concentricity		
																	[illegible]	[illegible]	[illegible]
[illegible]	1/4 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	5/16 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3/8 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	7/16 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1/2 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	9/16 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	3/4 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	1-1/2 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(a) [illegible]

(b) [illegible]

MATERIAL: [illegible] SEE PROCUREMENT SPECIFICATION.

FINISH: [illegible] SEE PROCUREMENT SPECIFICATION.

HEAT TREAT: SEE PROCUREMENT SPECIFICATION.

[illegible]

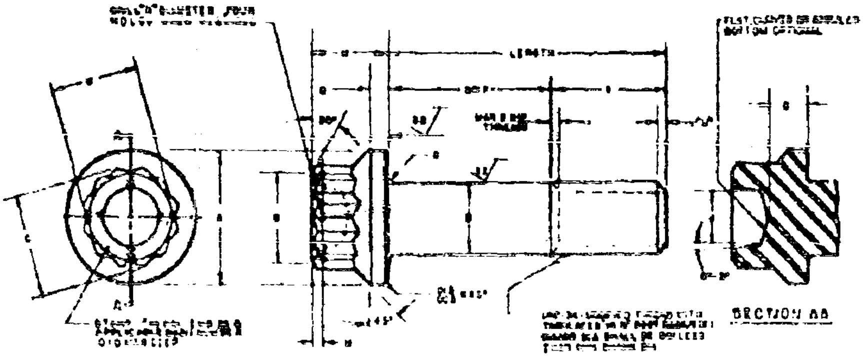
EXAMPLES OF PART NO.: [illegible]

[illegible] CONSTRUCTION OF DRILLED HOLES IS OPTIONAL.

DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±.010, ANGLES ±1°

CUSTODIANS [illegible]	MILITARY STANDARD	MS20004 THRU MS20024
PROCUREMENT SPECIFICATION [illegible]	BOLT - INTERNAL WRENCHING, 160,000 PSI	SHEET 1 OF [illegible]

FIGURE 1



CODE (A) PART NUMBER	THREAD	A	B	C	D	E	H	J	K	K	M	N	P	R	T	U	W	CONCENTRICITY X	Y	Z
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		[illegible]			[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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NOTES:

(A) [illegible] A, B, AND J TO BE CONCENTRIC [illegible]
[illegible]
[illegible]

(B) [illegible]

(C) HEAD OF BOLT TO BE FORGED
[illegible]
HEAD TO SHANK FILLET TO BE COLD WORKED
TENSILE STRENGTH TO BE [illegible] PSI
SHEAR STRENGTH TO BE [illegible] PSI MIN.

(D) [illegible]

CODE - FIRST DASH NUMBER DESIGNATES DIAMETER IN [illegible]
ADD H TO FIRST DASH NUMBER TO DESIGNATE DRILLED HEAD
SECOND DASH NUMBER DESIGNATES GRIP LENGTH IN SIXTEENTHS. [illegible]
[illegible]

EXAMPLE OF PART NUMBERS - [illegible]

FIGURE 2

Bolt, External Wrenching, 220,000 PSI Minimum

THIS
PAGE
IS
MISSING
IN
ORIGINAL
DOCUMENT

47

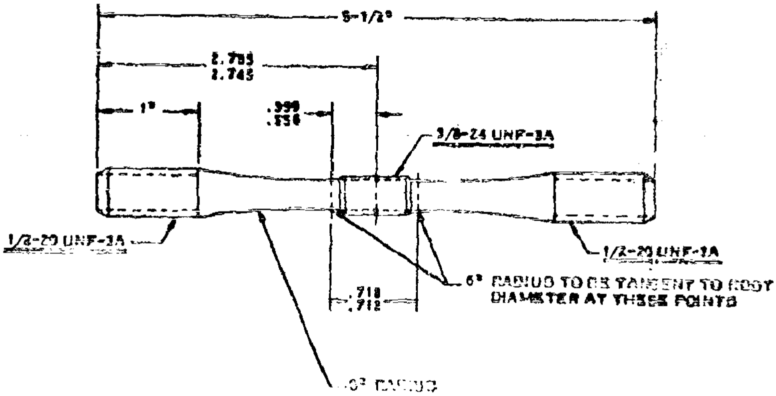


FIGURE 4

Initial Tension-Tension Fatigue Test Specimen for Determining the Characteristics of Unengaged Threads

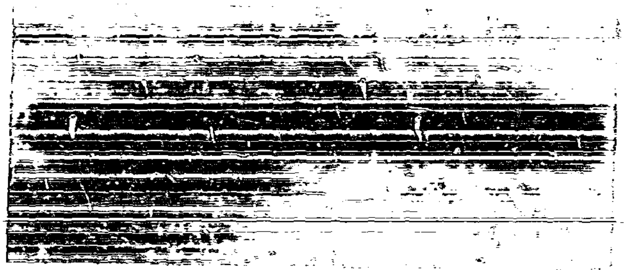


FIGURE 5

Tension-Tension Fatigue Fracture Located in the 1/2-20 Thread of the Above 3/8-24 Stud

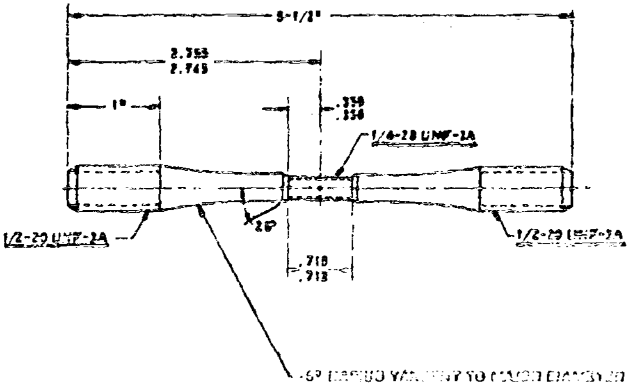


FIGURE 6

Second Tension-Tension Fatigue Test Specimen for Determining the Characteristics of Unengaged Threads

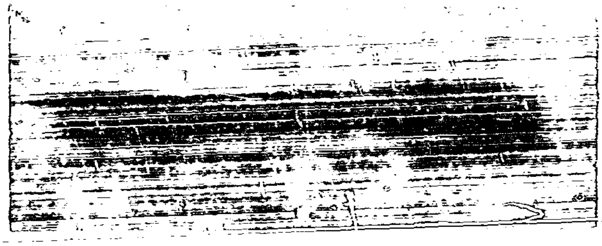
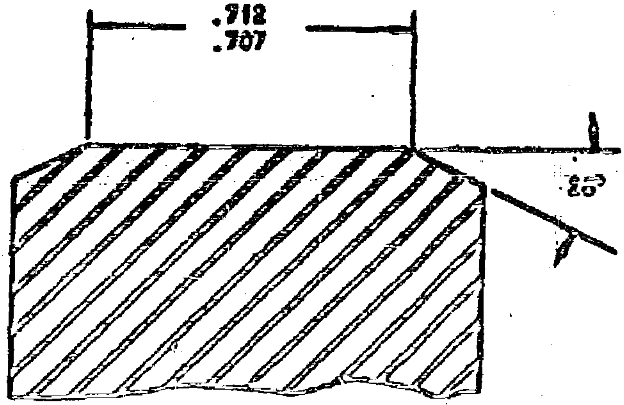


FIGURE 7

Tension-Tension Fatigue Fracture Located at the Thread Termination of the Above 1/4-28 Stud



STANDARD 1/4-20 MOD A
[illegible] WATERBURY
THREAD ROLL DIE
TYPE A

<u>FIGURE 8</u>

Special Thread Dies for Rolling Stud with Six Inch Radius Tangent to Thread Major Diameter

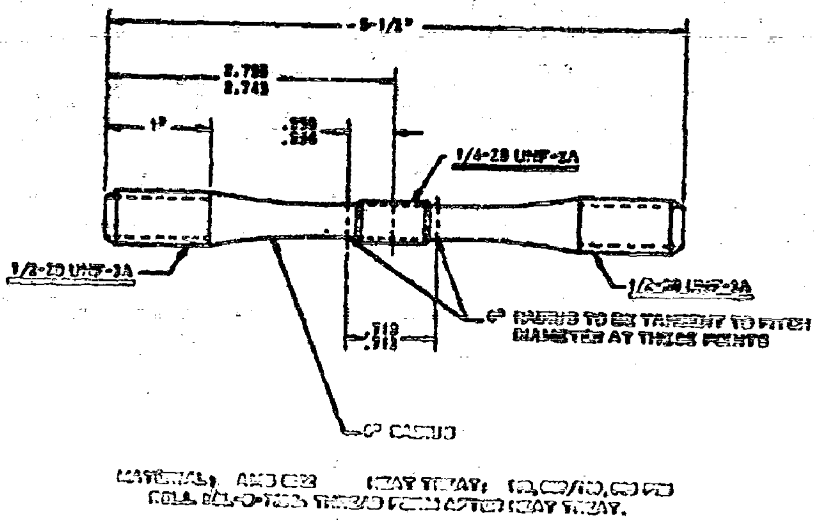


FIGURE 9

Third Tension-Tension Fatigue Test Specimen for Determining the Characteristics of Unengaged Threads

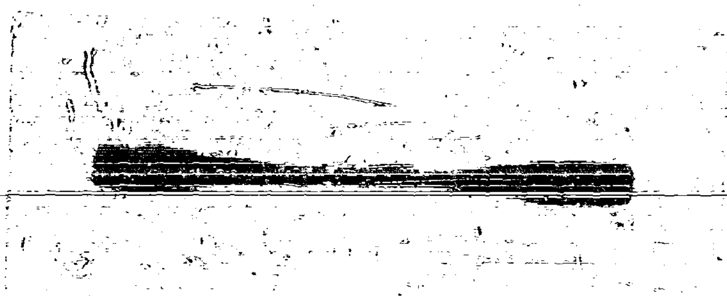


FIGURE 10

Tension-Tension Fatigue Fracture Located at the Thread Termination of the Above 1/4-28 Stud

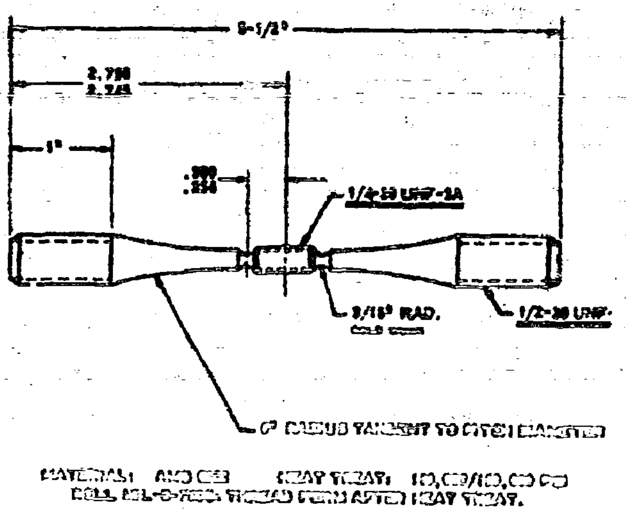


FIGURE 11

Fourth Design of Tension-Tension Fatigue Test Specimen for Determining the Characteristics of Unengaged Threads

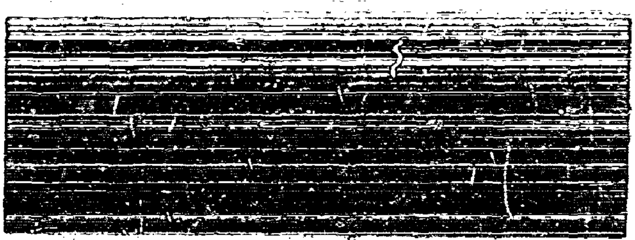


FIGURE 12

Tension-Tension Fatigue Fracture Located at the Termination of the Above 1/4-28 Stud

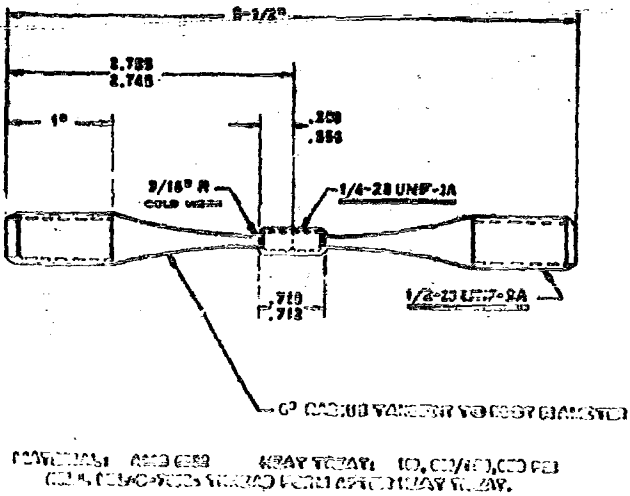


FIGURE 13

Fifth Design of Tension-Tension Fatigue Test Specimen for Determining the Characteristics of Unengaged Threads

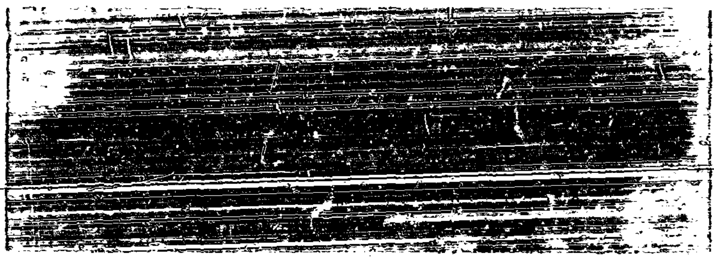


FIGURE 14

Tension-Tension Fatigue Fracture Located in Last Full Thread of the Above Stud

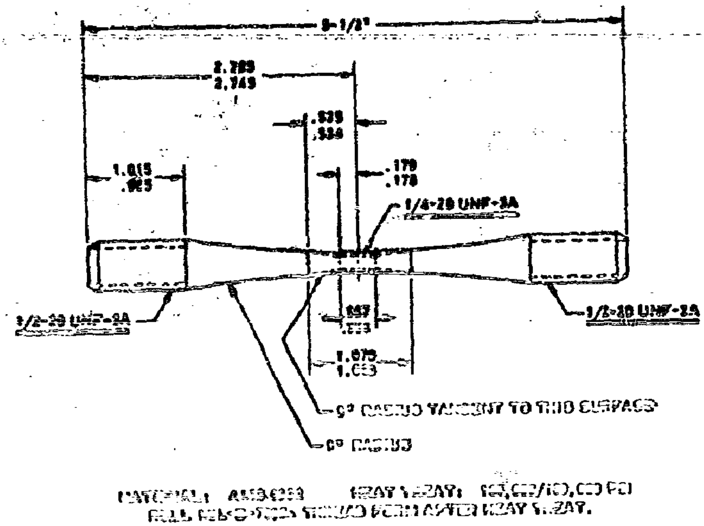


FIGURE 15

Sixth Design of Tension-Tension Fatigue Test Specimen for Determining the Characteristics of Unengaged Threads

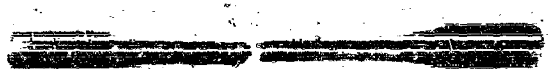


FIGURE 16

Tension-Tension Fatigue Fracture of the Above Stud Located at the Junction of the Taper and Full Thread

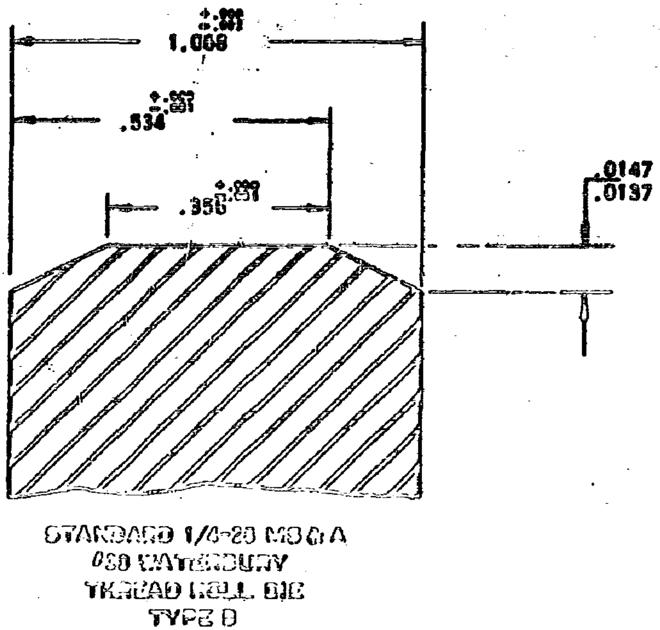


FIGURE 17

Cross Section of Special Thread Roll Dies used to Produce Studs with Tapered Runout

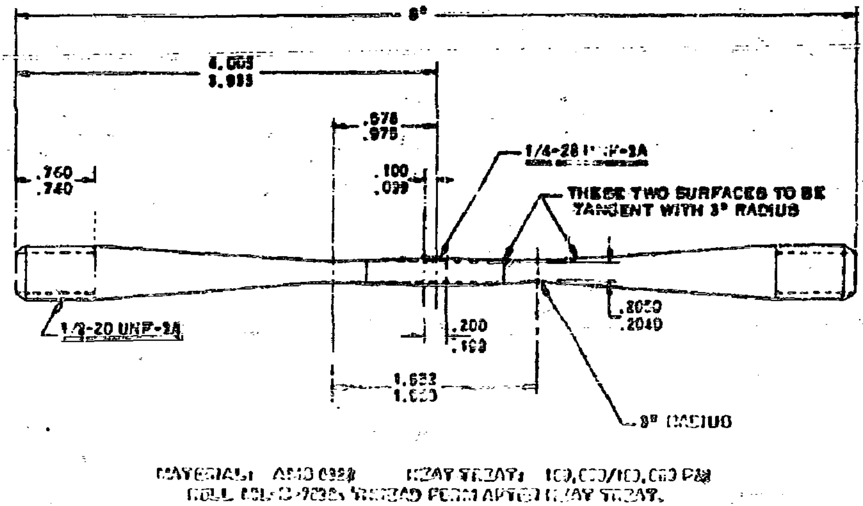


FIGURE 18

Seventh Design of Tension-Tension Fatigue Test Specimen to Determine the Characteristics of Unengaged Threads

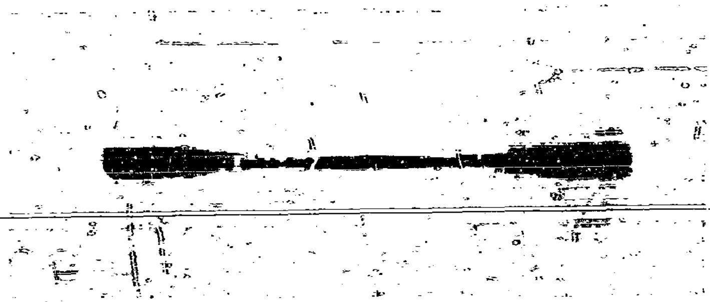
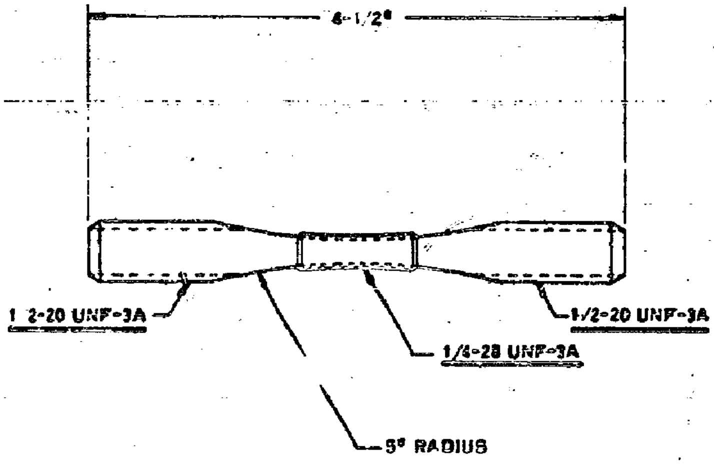


FIGURE 19

Tension-Tension Fatigue Fracture of the Above Stud Located at the Junction of the Tapers from the Threads



MATERIAL: AMS 6322 HEAT TREAT: 160,000/180,000 PSI
ROLL MIL-S-7742, THREAD FORM AFTER HEAT TREAT.

FIGURE 20

Eighth Design of Tension-Tension Fatigue Specimen to Determine the Characteristics of Unengaged Threads

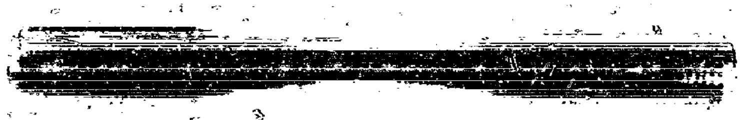
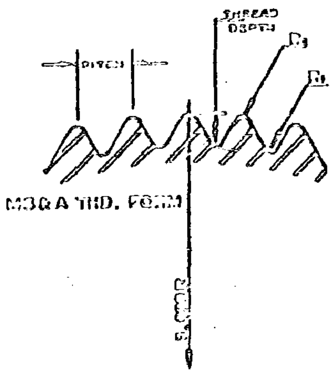
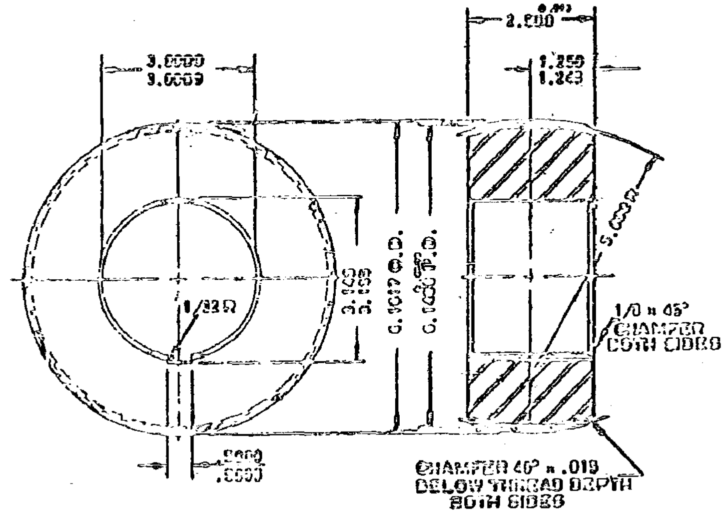


FIGURE 21

Appearance of the Above Stud after Rolling
Note Slivers of Metal and Incomplete Thread Form on Part of Stud





NOTES:
1. I.D. & O.D. TO BE CONCENTRIC WITHIN .0003 TIR.
2. END SURFACES TO BE PARALLEL & SQUARE WITH BORE WITHIN .0002 TIR.
3. GRIND THREADS AFTER HEAT TREAT.
4. GRIND THREADS LEFT HAND

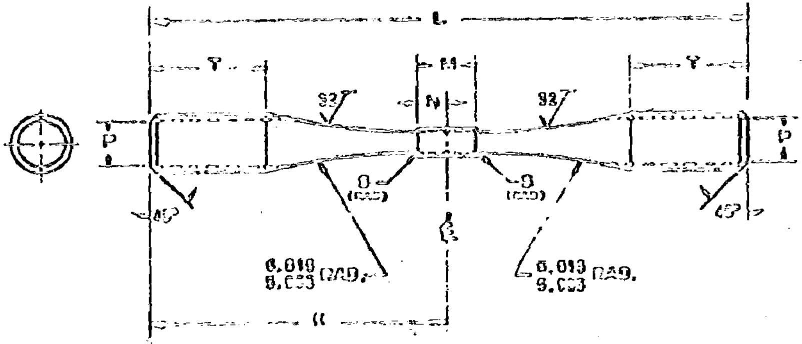
SIZE	THREAD DEPTH	PITCH	LEAD	HELIX ANGLE	RAD. R1	R2	NO. OF LEADS
1/4-28	.0229 .0219	.03571	1.0000	2°33'	.0040	.0040 .0030	28

FIGURE 22

Special Thread Roll Dies used to try to Produce 1/4-28 Thread on the Curved Surface

NOTED:

1. LARGE RADIUS TO BE TANGENT TO ROOT DIA. AT JUNCTION OF LARGE AND SMALL RADIUS.



ROOT THD. SIZE	SMALL THD.	LARGE THD.	L ±.010	R		M		N		P		S		Y	
				MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
1/4	1/4-28	1/2-20	8.140	2.878	2.853	[illegible]	.657	.2515	.2493	.399	.389	.033	.030	1.010	.963
3/8	3/8-24	3/4-16	6.625	[illegible]	3.435	.753	.737	.3765	.3725	.630	.618	.162	.160	1.518	1.485
1/2	1/2-20	1"-14	[illegible]	4.819	4.269	1.009	.997	.5018	[illegible]	.937	.927	.122	.120	2.018	1.989
5/8	5/8-18	1-1/8-12	9.378	4.655	4.635	1.563	1.647	.7515	.7485	1.313	1.303	.142	.142	1.680	1.650
1"	1"-14	1-3/8-12	10.992	5.501	5.491	2.003	1.997	1.0015	.9985	1.557	1.547	.162	.160	2.018	1.989

FIGURE 23

Final Design of Studs used to Determine the Tension-Tension Fatigue Characteristics of Unengaged Threads

FIGURE 24

Profile of Threads to MIL-B-7838 on 3/4 Stud

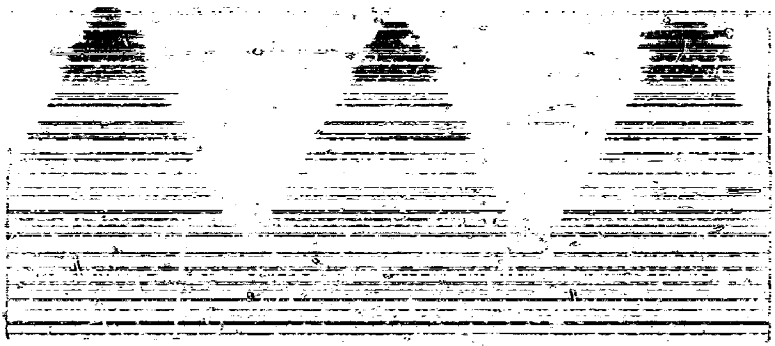


FIGURE 25

**Profile of Threads Cut to MIL-S-7742 on 3/4 Studs
Note Flat Root with Small Radii Blending to Flanks**

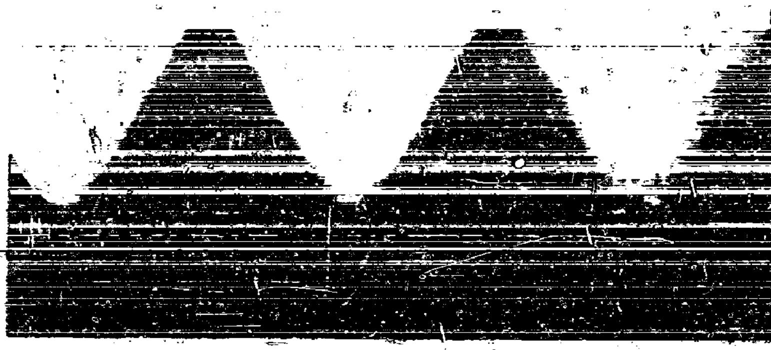


FIGURE 26

**Profile of Threads to High Radius Form on 3/4 Studs
Note Large Radius in Root of Thread**

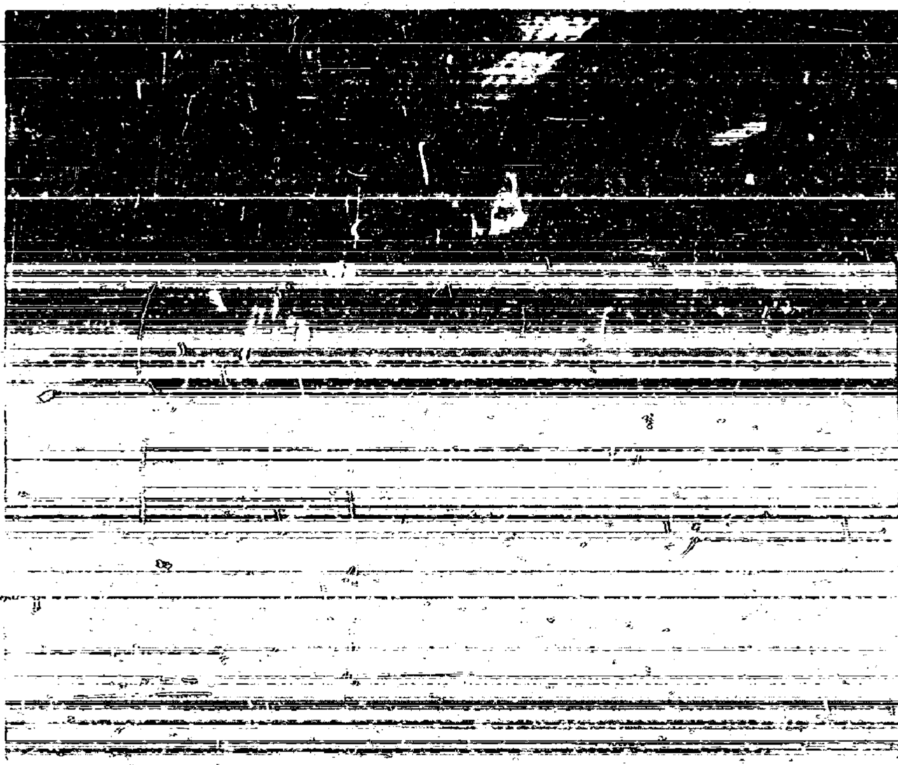


FIGURE 27

30,000# Tinius Olsen Electomatic Universal Testing Machine

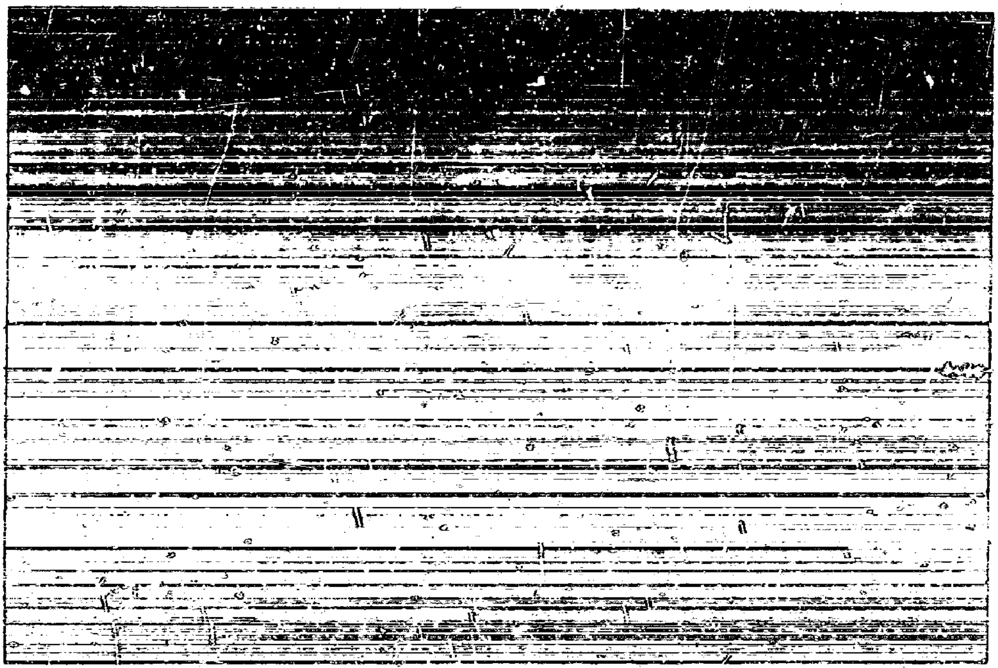


FIGURE 28

60,000# Tinius Olsen Super "L" Hydraulic Universal Testing Machine

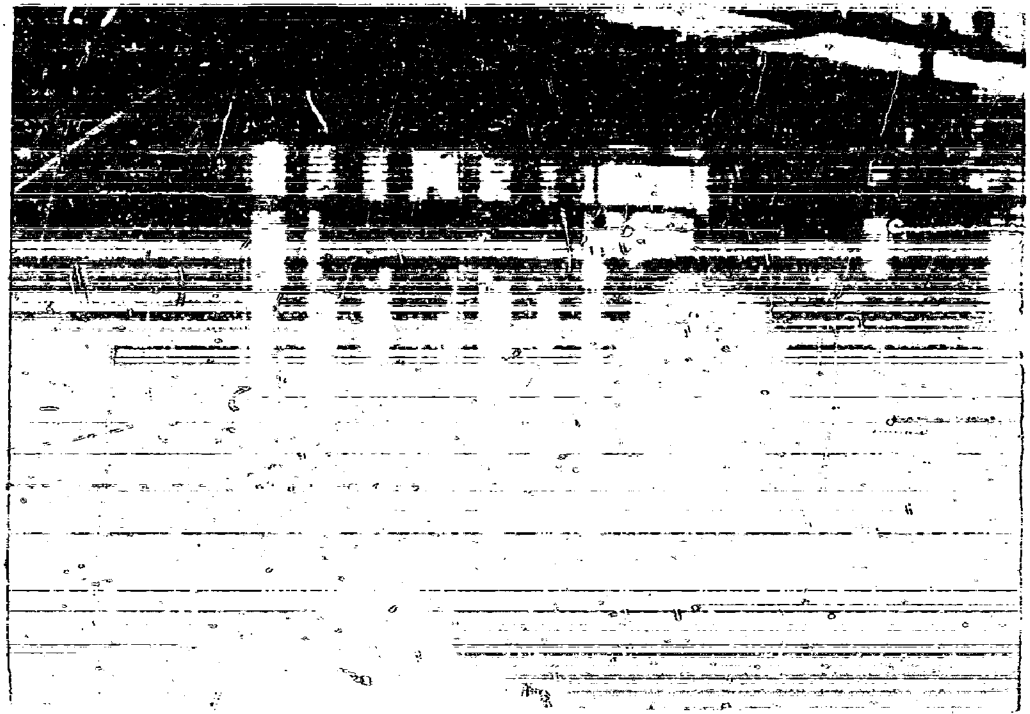


FIGURE 29

120,000# Tinius Olsen Electomatic Universal Testing Machine

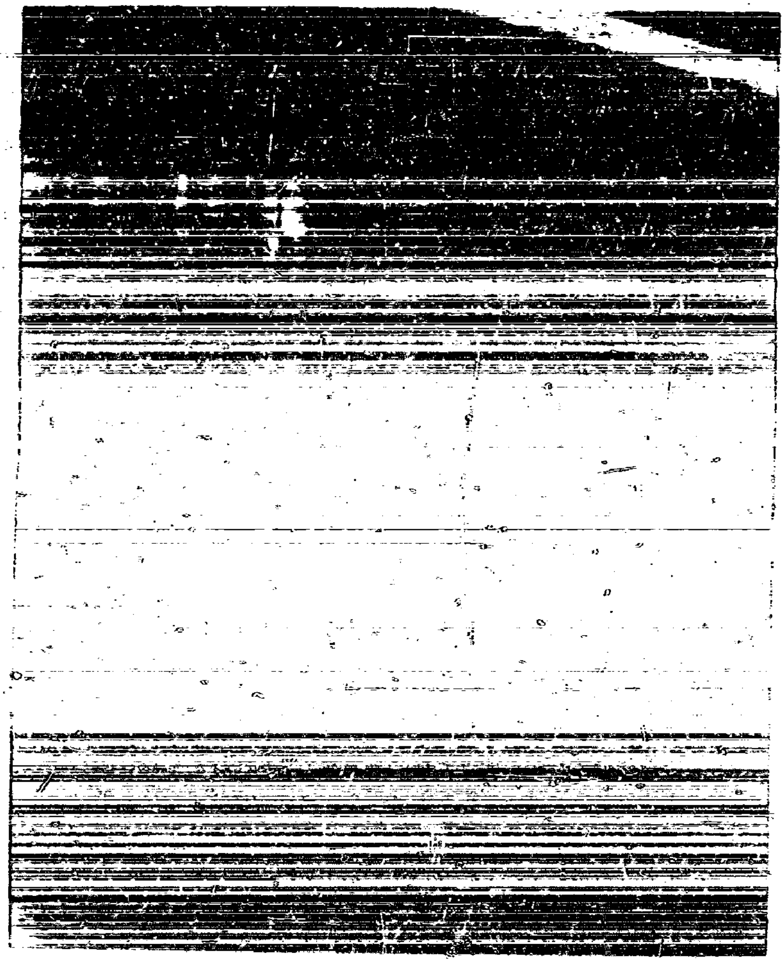


FIGURE 30

400,000# Tinius Olsen Super "L" Hydraulic Universal Testing Machine

FIGURE 31

Provi Rings for Calibration of Tensile Machines

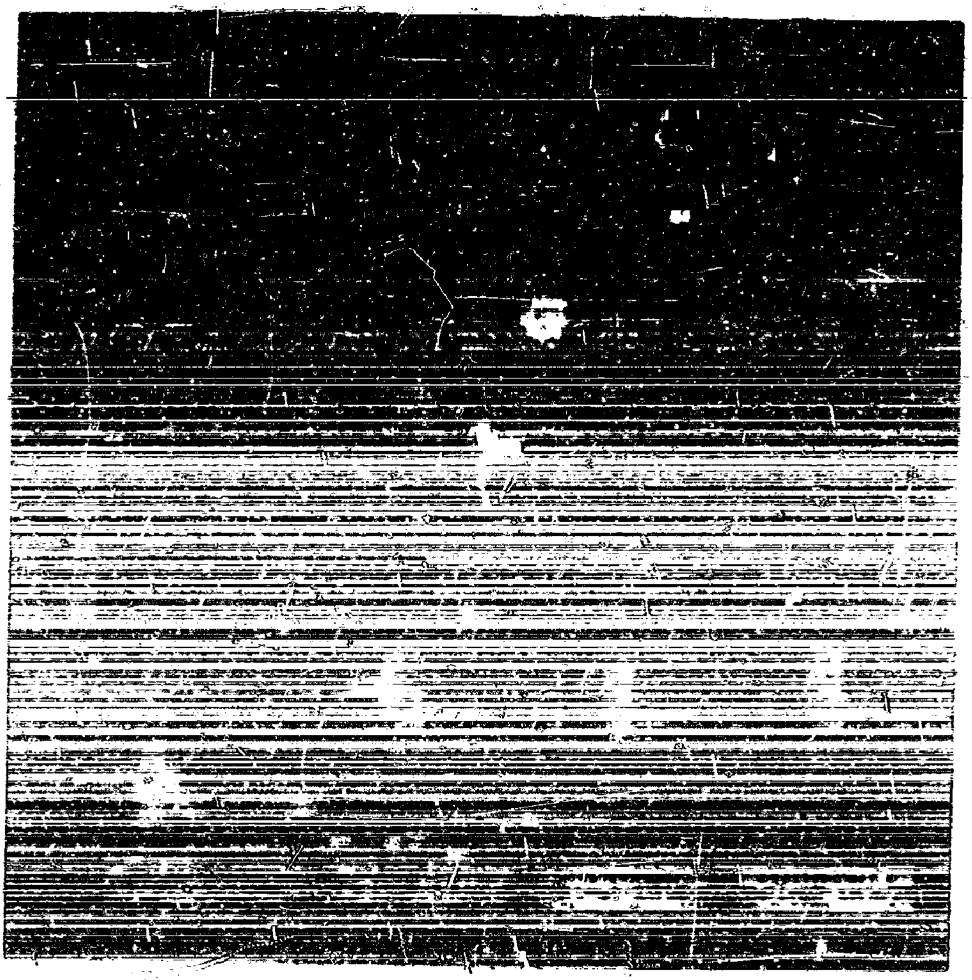


FIGURE 32

Extensometers used in Tensile Testing

FIGURE 33

Specimen Extensometer Assembled in Tensile Machine

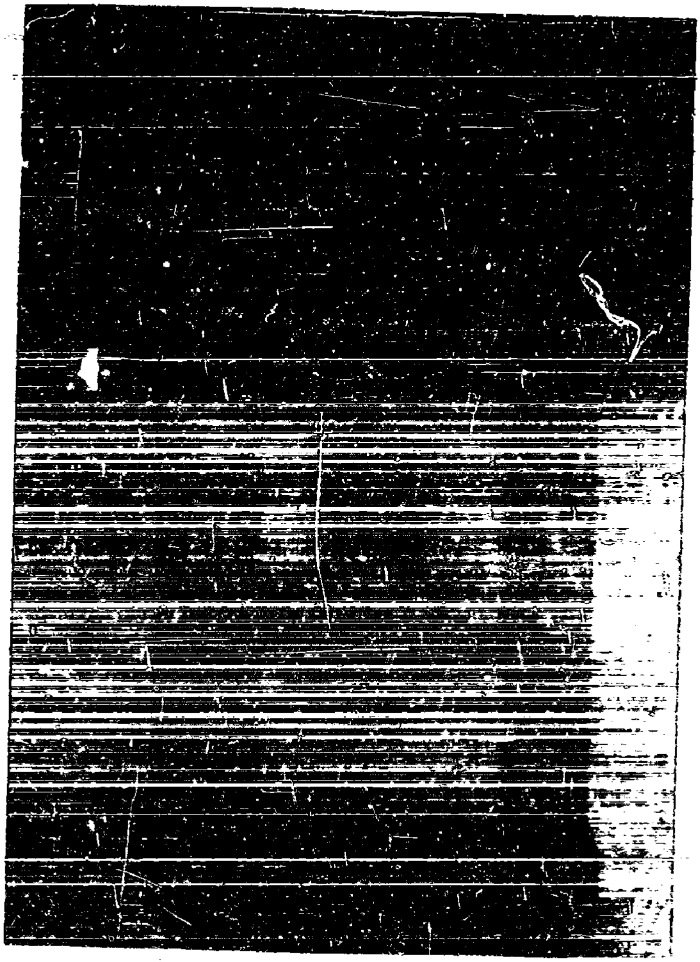
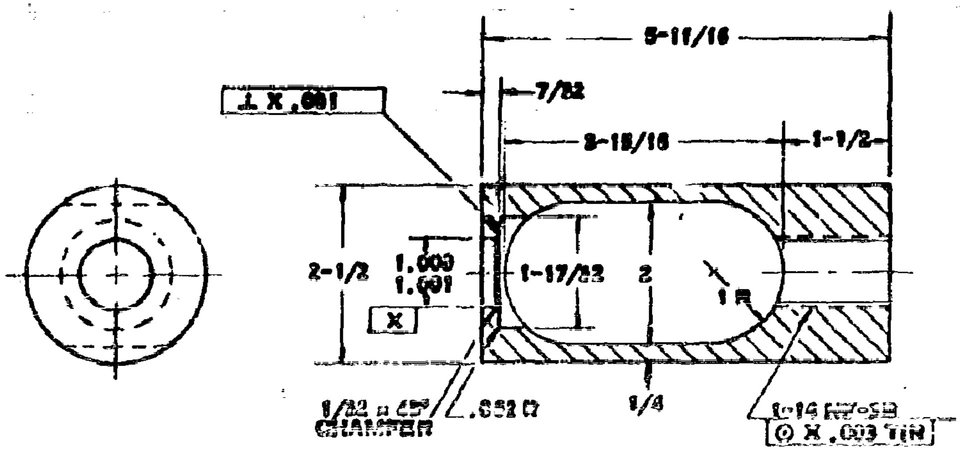


FIGURE 34

Bolt Extensometer Being used on 60,000# Tensile Machine

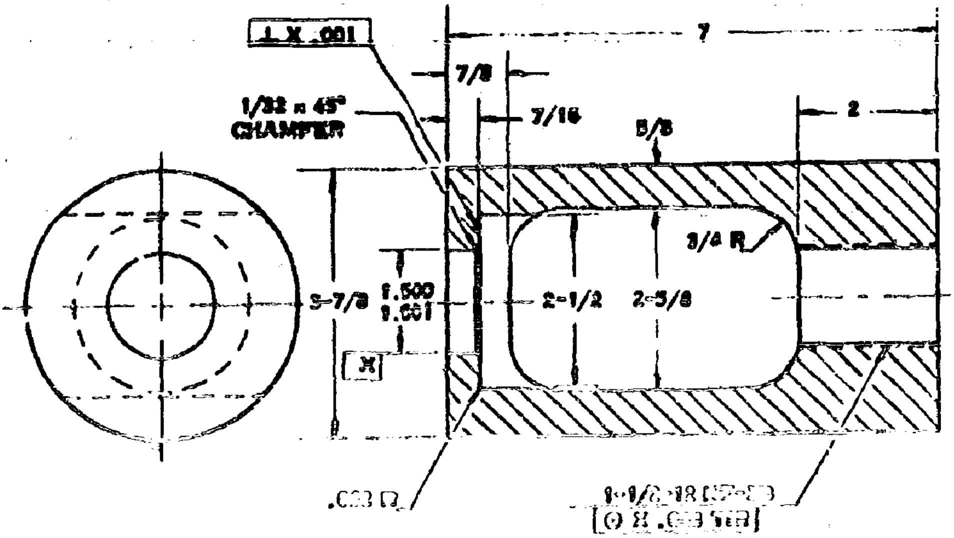


NOTES:

1. TOLERANCES UNLESS SPECIFIED: FRACTIONS ± 1/64, DECIMALS ± .010, ANGLES ± 2°
2. SURFACE FINISH: 60 RMS.
3. MATERIAL: 40 CARBON STEEL.
4. HEAT TREAT: 35-39 R_c

FIGURE 35

Testing Link, 3,000 Pound Capacity

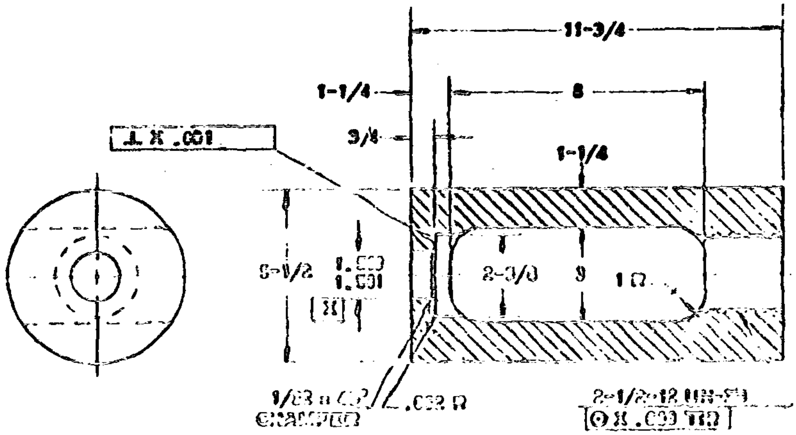


NOTES:

1. TOLERANCES UNLESS SPECIFIED: FRACTIONS ±1/64 DECIMALS ±.010
   ANGLES ±1°
2. SURFACE FINISH 63 RMS
3. MATERIAL: 40 CARBON ALLOY STEEL
4. HEAT TREAT: 35-39 R_c

FIGURE 36

Testing Link, 15,000 Pound Capacity

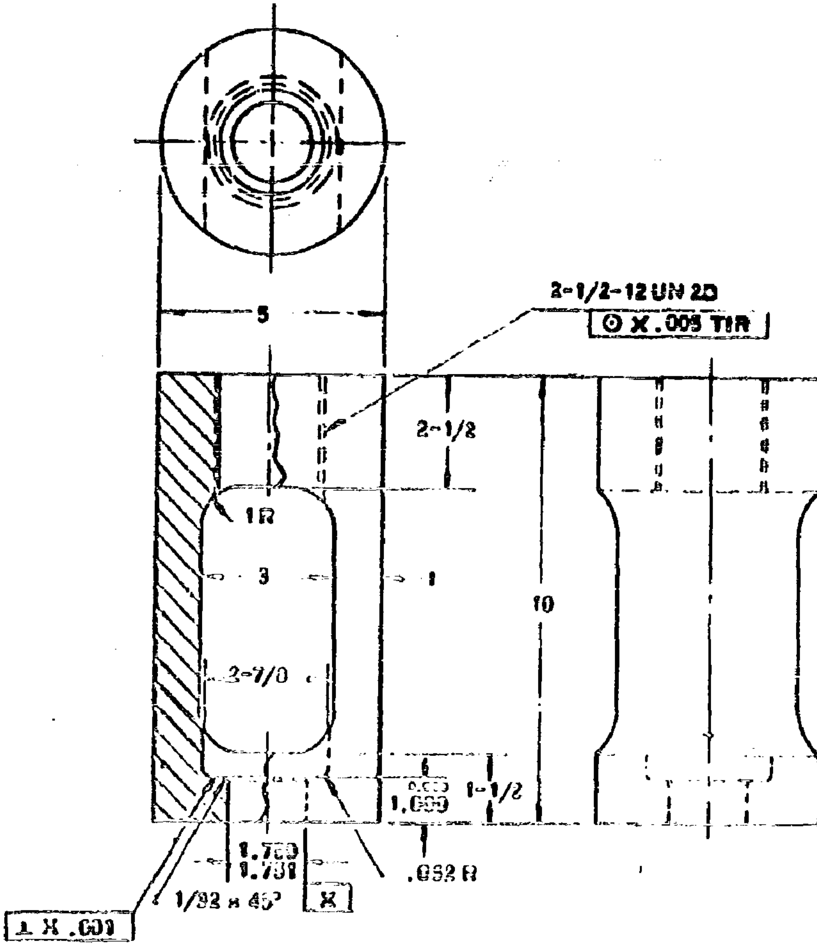


NOTES:

1. TOLERANCES UNLESS SPECIFIED: FRACTIONS ± 1/64, DECIMALS ± .010, ANGLES ± 2°.
2. ~~SURFACE FINISH; 63 RMS~~
3. MATERIAL: 40 CARBON ALLOY.
4. HEAT TREAT: 33-35 R_c

FIGURE 37

Testing Link, 60,000 Pound Capacity

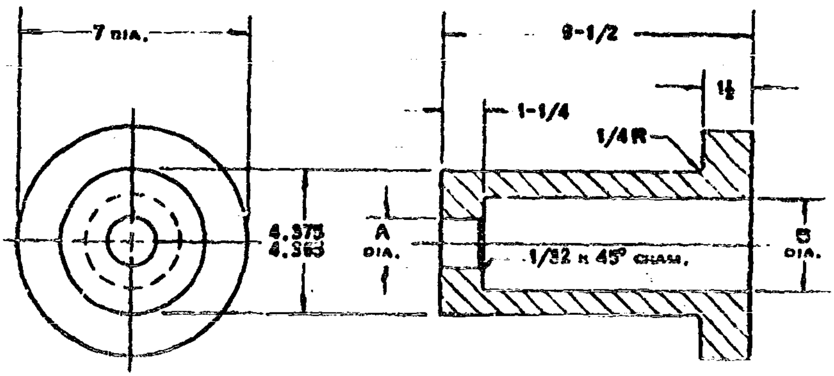


NOTES:

1. ALL RADII SHALL BE A SMOOTH BLEND.
2. BREAK ALL SHARP EDGES.
3. MATERIAL: 40 CARBON ALLOY STEEL.
4. HEAT TREAT: 32-35 R_c.
5. TOLERANCES UNLESS SPECIFIED: FRACTIONS ± 1/64, DECIMALS ±.010, ANGLES ± 2°

FIGURE 38

Testing Link, 120,000 Pound Testing Machine



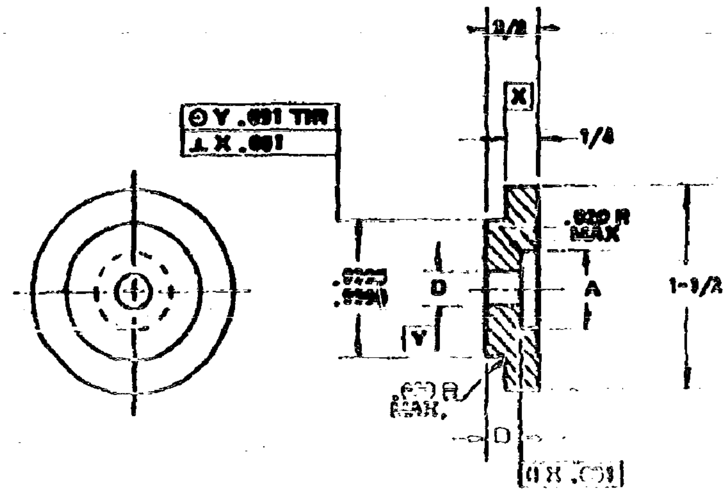
[illegible] SIZE	A +0.000 -0.005	B +0.010 -0.000
3/4	.7[illegible]	1.453
7/8	.850	1.6[illegible]
1	1.0[illegible]	1.[illegible]
1-1/8	1.180	2.110
1-1/4	1.[illegible]	2.[illegible]
1-3/8	1.[illegible]	2.[illegible]
1-1/2	1.[illegible]	2.[illegible]

NOTES:

1. MATERIAL: 4340 STEEL.
2. HEAT TREAT 35-40 Rc
3. TOLERANCE UNLESS SPECIFIED: FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±2°.

FIGURE 39

Adaptor for Top Crosshead 400,000 Pound Tensile Machine



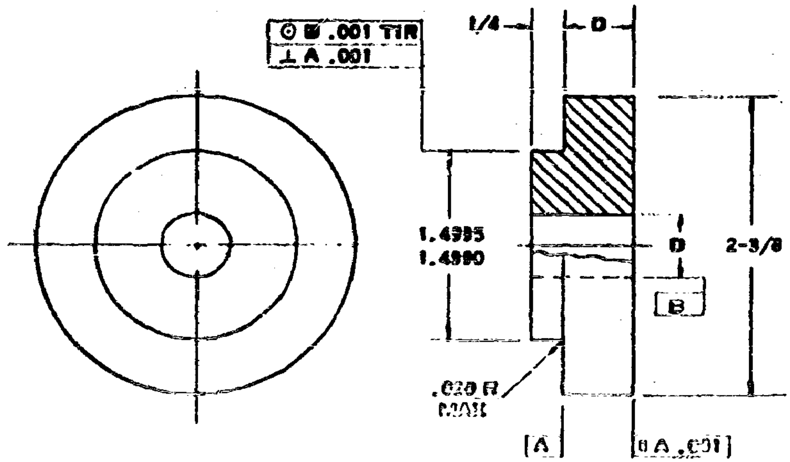
[illegible]	A	B	D	
			MIN	MAX
[illegible]	.553	.1[illegible]3	.181	.183
1/4	.582	.2[illegible]	.251	.253

NOTES:

1. TOLERANCES UNLESS SPECIFIED: FRACTIONS ± 1/64, DECIMALS ± .010, ANGLES ± 2°
2. SURFACE FINISH: 63 RMS
3. MATERIAL: [illegible] CARBON STEEL
4. HEAT TREAT: 33-38 R_c

FIGURE 40

Counterbored Adapter 3,000 Pound Testing Link



BOLT SIZE	D MIN	D MAX
#10	.191	.192
1/4	.251	.252
5/16	.313	.314
3/8	.376	.377
7/16	.438	.439
1/2	.501	.502
9/16	.563	.564
5/8	.626	.627
3/4	.751	.752
7/8	.876	.877
1	1.001	1.002

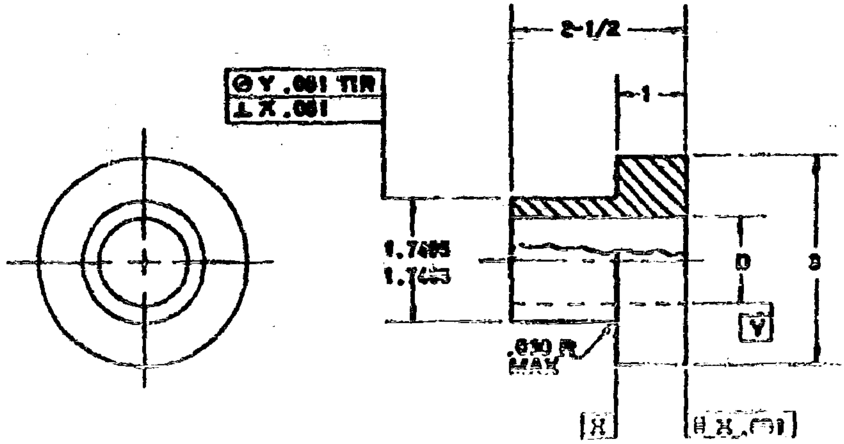
3 ± .010,

NOTES:

1. TOLERANCE UNLESS SPECIFIED: FRACTIONS ± 1/64, DECIMALS ± .010,
   ANGLES ± 2°
2. SURFACE FINISH: 63 RMS
3. MATERIAL: 40 CARBON STEEL
4. HEAT TREAT: 35-38 R

FIGURE 41

Adapter for 15,000 and 60,000 Pound Fatigue Link



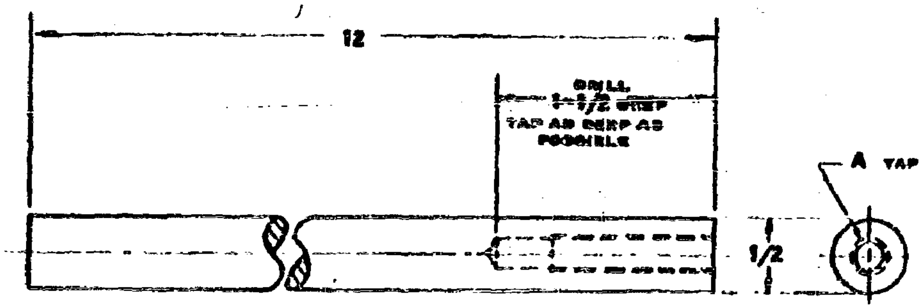
BOLT SIZE	D	
	MIN	MAX
1	1.031	[illegible]
1-1/8	1.125	1.127
1-1/4	1.251	[illegible]
1-3/8	1.376	1.377
1-1/2	1.501	1.502

NOTES:

1. TOLERANCES UNLESS SPECIFIED: FRACTIONS ±1/64, DECIMALS ±.010, ANGLES ±5°
2. SURFACE FINISH: 60 RMS
3. MATERIAL: 40 CARBON STEEL
4. HEAT TREAT: 53-58 R_c

FIGURE 42

Adapter 120,000 Pound Fatigue Link



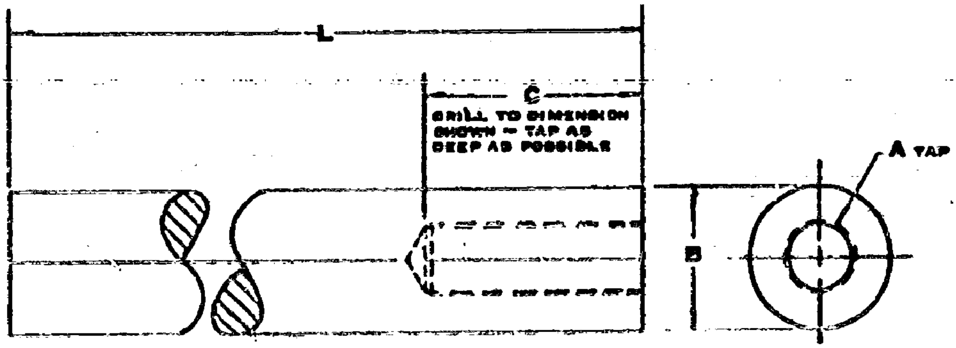
A TAP SIZE
#8-36 NF-2A
#8-32 NC-2A
#10-32 NF-2A
#10-24 NC-2A
1/4-28 UNF-2A
1/4-20 UNC-2A

NOTES:

1. MATERIAL: [illegible] CARBON STEEL.
2. HEAT TREAT 20-35 R_c
3. TOLERANCE UNLESS SPECIFIED: FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±2°.

FIGURE 43

Tapped Bars for Tensile Testing Machine



A TAP SIZE	B	C	L
5/16-24	5/8	1-1/2	12
5/16-18	5/8	1-1/2	12
3/8-24	3/4	1-1/2	12
3/8-16	3/4	1-1/2	12
7/16-20	7/8	1-1/2	12
7/16-14	7/8	1-1/2	12
1/2-20	1	1-1/2	12
1/2-13	1	1-1/2	12
9/16-18	1-1/8	1-3/4	12
9/16-12	1-1/8	1-3/4	12
5/8-18	1-1/8	1-3/4	12
5/8-11	1-1/4	1-3/4	12

A TAP SIZE	B	C	L
3/4-16	1-1/2	2	18
3/4-10	1-1/2	2	18
7/8-14	1-3/4	2-1/2	18
7/8-9	1-3/4	2-1/2	18
1-14	2	2-1/2	18
1-8	2	2-1/2	18
1-1/8-12	2-1/4	2-1/2	18
1-1/8-7	2-1/4	2-1/2	18
1-1/4-12	2-1/2	3	18
1-1/4-7	2-1/2	3	18
1-3/8-12	2-3/4	3	18
1-3/8-6	2-3/4	3	18

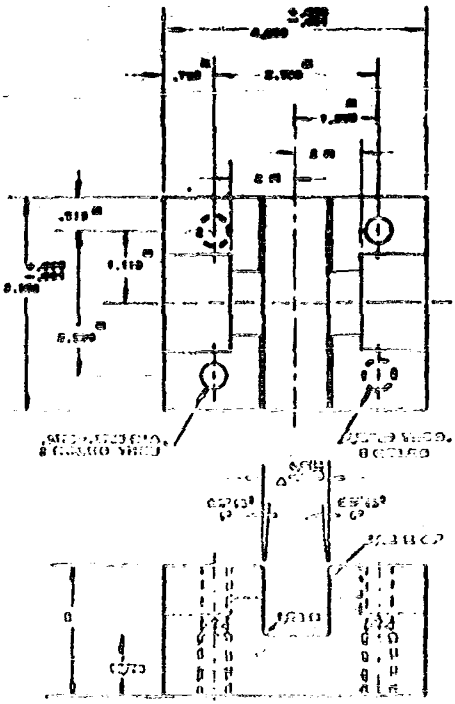
A TAP SIZE	B	C	L
1-1/2-12	3	3-1/2	18
1-1/2-6	3	3-1/2	18
1-5/8-12	3-1/4	3-1/2	18
1-5/8-[illegible]	3-1/4	3-1/2	18
1-3/4-12	3-1/2	4	23
1-3/4-5	3-1/2	4	23
1-7/8-12	3-3/4	4	23
1-7/8-5	3-3/4	4	23
2-12	4	4-1/2	23
2-4-1/2	4	4-1/2	23

NOTES:

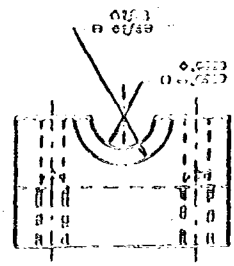
1. MATERIAL: 40 CARBON STEEL.
2. HEAT TREAT 30-35 R_c
3. TOLERANCE UNLESS SPECIFIED: FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±2°.

FIGURE 44

Tapped Bars for Tensile Testing Machine



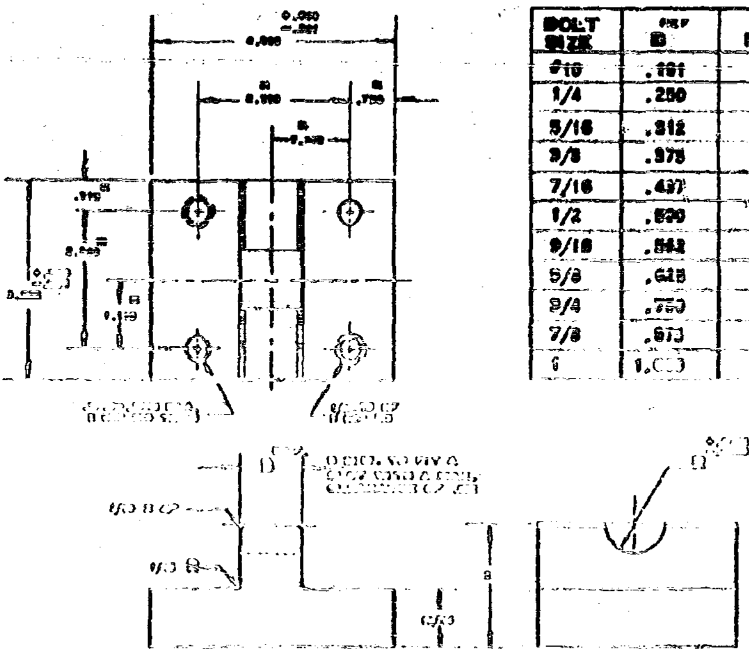
BOLT SIZE	A [illegible]	R
#10	.190	.095
1/4	.251	.126
5/16	.313	.157
3/8	.376	.188
7/16	.438	.219
1/2	.501	.251
9/16	.563	.282
5/8	.625	.313
3/4	.751	.376
7/8	.876	.438
1"	1.001	.501



NOTES:
1. DIES TO BE LOCATED ON A [illegible] POSITION (35°-45°) ON DIE SET TO ALLOW SHEARING OF LONG [illegible].
2. a THE LOCATION OF HOLES DISTINGUISHED WITH a ARE TO BE JIG DRILLED. USE JIG TH400J.
3. MATERIAL: D-2 STEEL
4. HEAT TREAT: 60-62 R_c
5. TOLERANCE UNLESS SPECIFIED. FRACTIONS ±1/64, DECIMALS ±.002 ANGLES ±1°

FIGURE 45

Bottom Shearing Die Shearing #10 to 1" Diameter



BOLT SIZE	D	R
#10	.191	[illegible]
1/4	.250	.125
5/16	.312	.157
3/8	.375	.188
7/16	.437	.219
1/2	.500	.251
9/16	.562	.282
5/8	.625	.313
3/4	.750	.375
7/8	.875	.438
1	1.000	.501

NOTES:
1. DIES TO BE LOCATED IN A DIAGONAL POSITION (35°-45°) ON DIE SET TO ALLOW SHEARING OF LONG PIECES.
2. ⊕ THE LOCATION OF HOLES DIMENSIONED WITH ⊕ ARE TO BE JIG DRILLED. USE JIG TR [illegible] J.

FIGURE 44

Top Shearing Die Shearing #10 to 1" Diameter

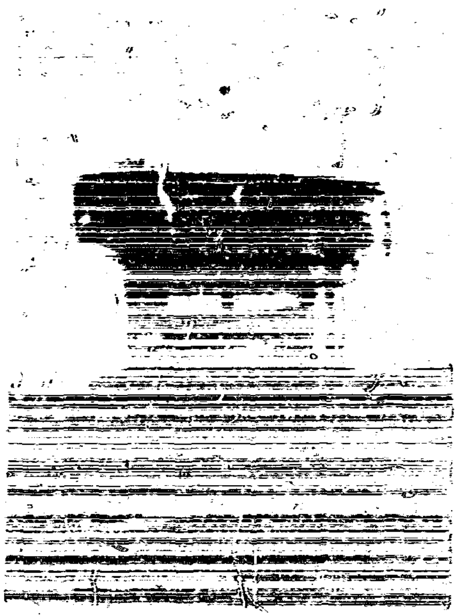


FIGURE 47

Setup for Shear Test on Bolts

FIGURE 48

5,000# Krouse Direct Stress Fatigue Machine
with Hydraulic Load Maintainers

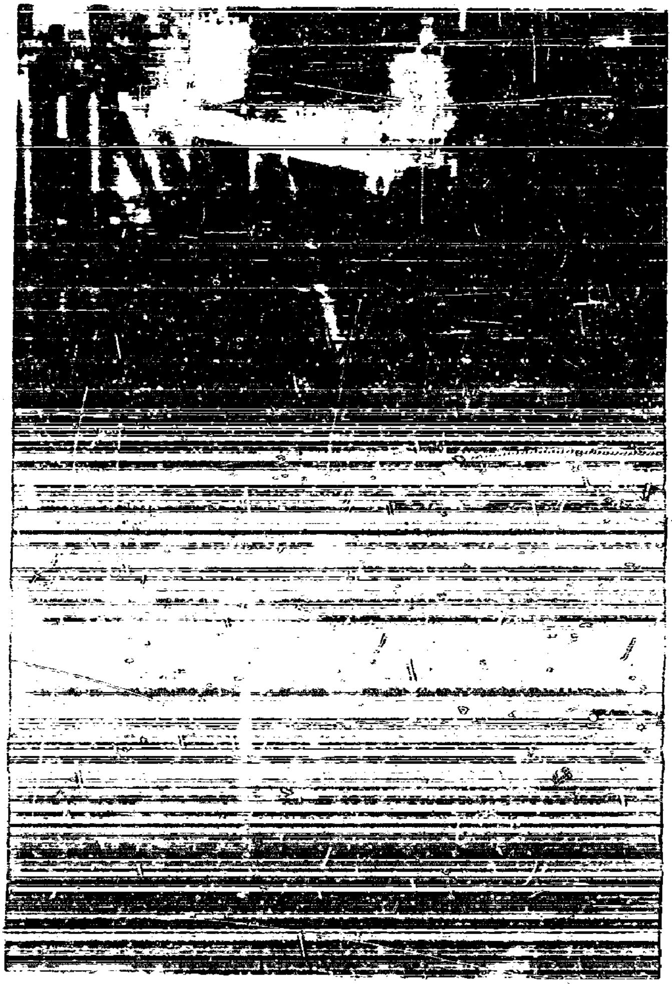


FIGURE 49

15,000# Krouse Direct Stress Fatigue Machine with Hydraulic Load Maintainer

FIGURE 50

60,000# Ivy Inertia Compensated Fatigue Machine

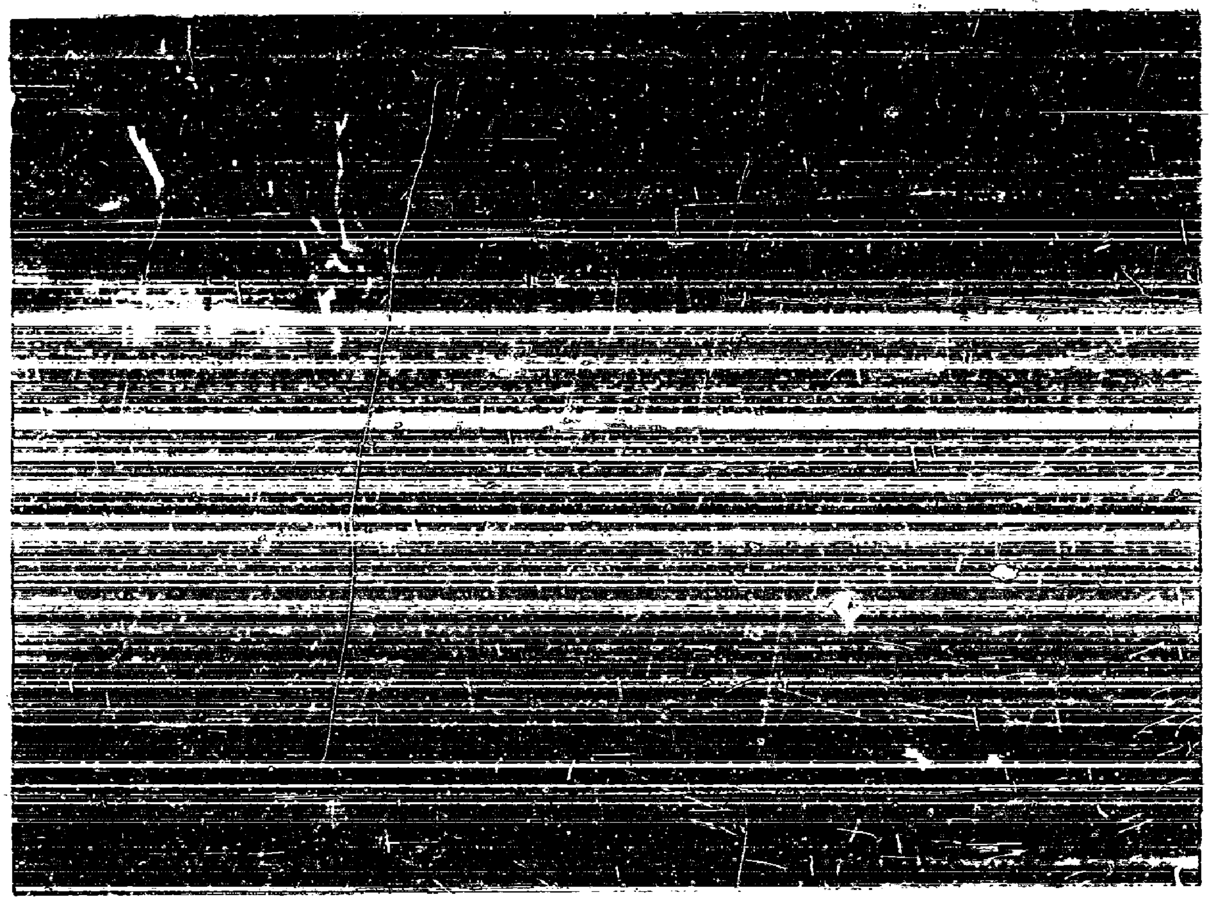


FIGURE 51

60,000# Krouse Fatigue Machine

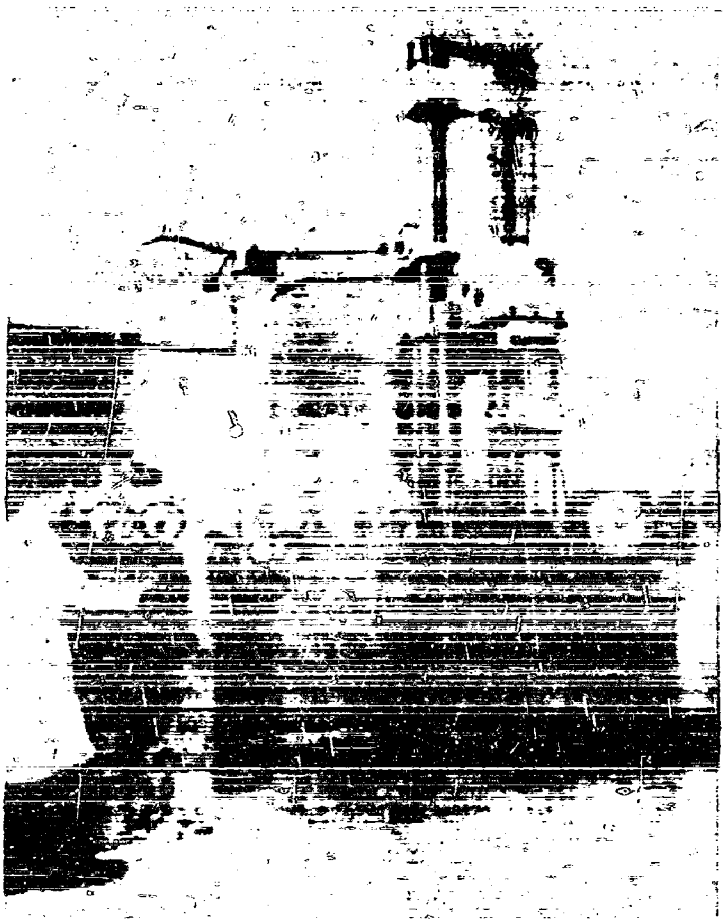


FIGURE 52

220,000# Amsler Fatigue Machine

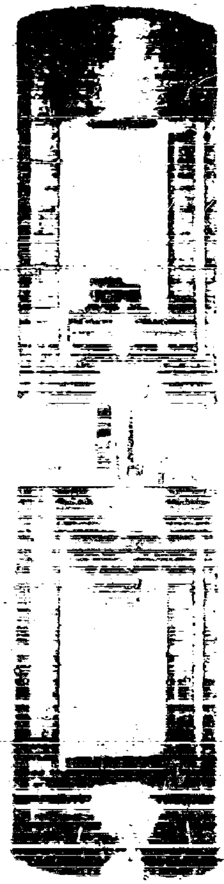
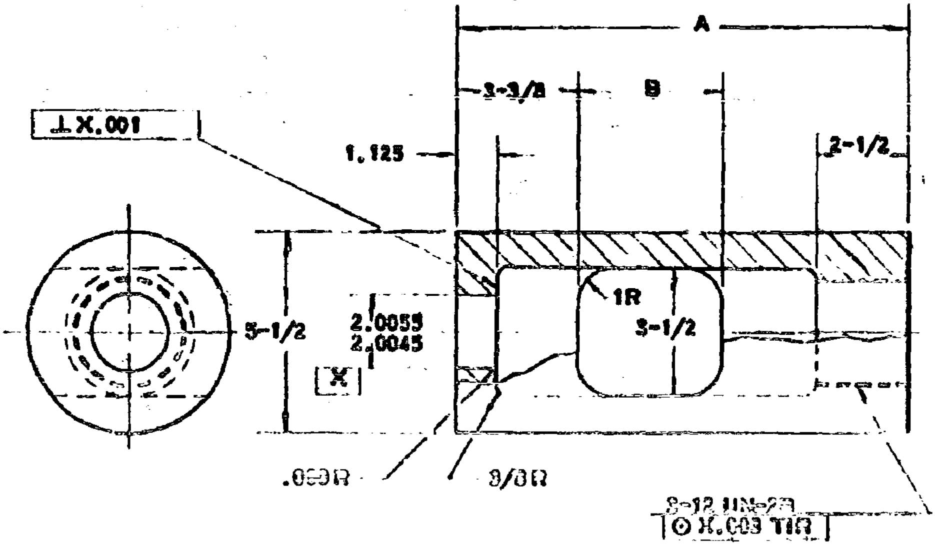


FIGURE 53

Fixture and Adapter Assembly used in Fatigue Testing Bolts



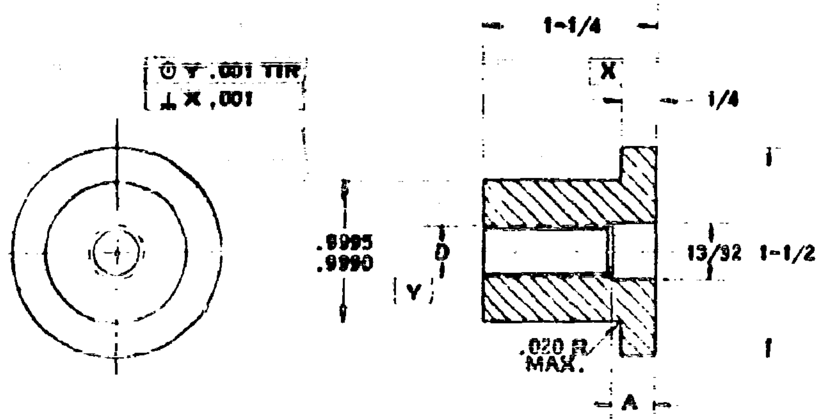
	A	B
TOP LINK	10-1/2	10
BOTTOM LINK	12-1/2	4

NOTES:

1. ALL RADII MUST BE A SMOOTH BLEND.
2. TOLERANCES UNLESS SPECIFIED:
   FRACTIONS ±1/64, DECIMALS ±.010, ANGLES ±2°.
3. MATERIAL: 40 CARBON ALLOY STEEL.
4. HEAT TREAT: 32-35 R_c

FIGURE 54

220,000 Pound Tension Fatigue Adapter



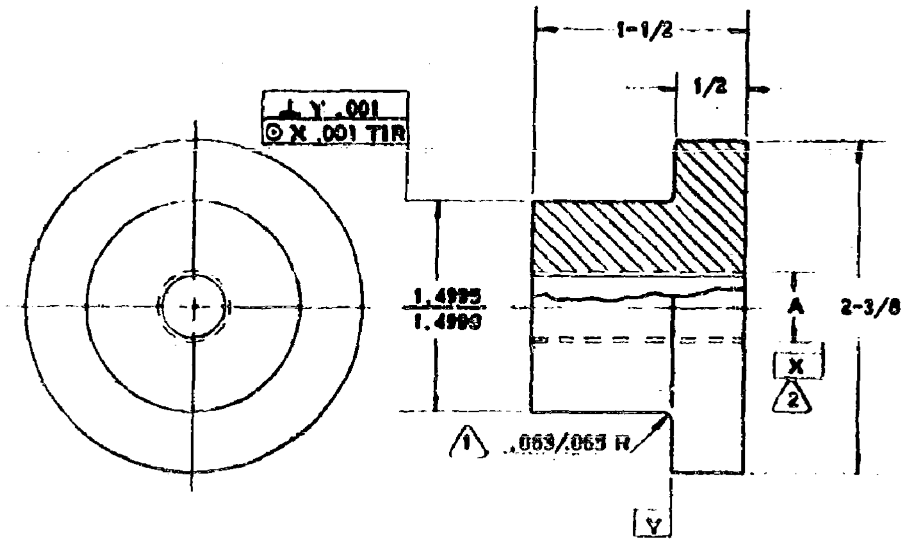
D	A
#10-32 NF	23/32
1/4-20 NC	3/8
1/4-28 NF	3/8
5/16-18 NC	13/32
5/16-24 NF	13/32
3/8-16 NC	5/16
3/8-24 NF	5/16

NOTES:

1. THREADS TO BE CLASS 3A.
2. TOLERANCE UNLESS SPECIFIED: FRACTIONS ± 1/64, DECIMALS ± .010, ANGLES ± 2°.
3. SURFACE FINISH: 60 RMS.
4. MATERIAL: 40 CARBON STEEL
5. HEAT TREAT: 53-58 R_c

FIGURE 55

Threaded Adapter 3,000 Pound Fatigue Link



A
#10-32 NF
1/4-20 NC
1/4-28 NF
5/16-18 NC
5/16-24 NF
3/8-16 NC
3/8-24 NF

A
7/16-14 NC
7/16-20 NF
1/2-13 NC
1/2-20 NF
9/16-12 NC
9/16-18 NF
5/8-11 NC

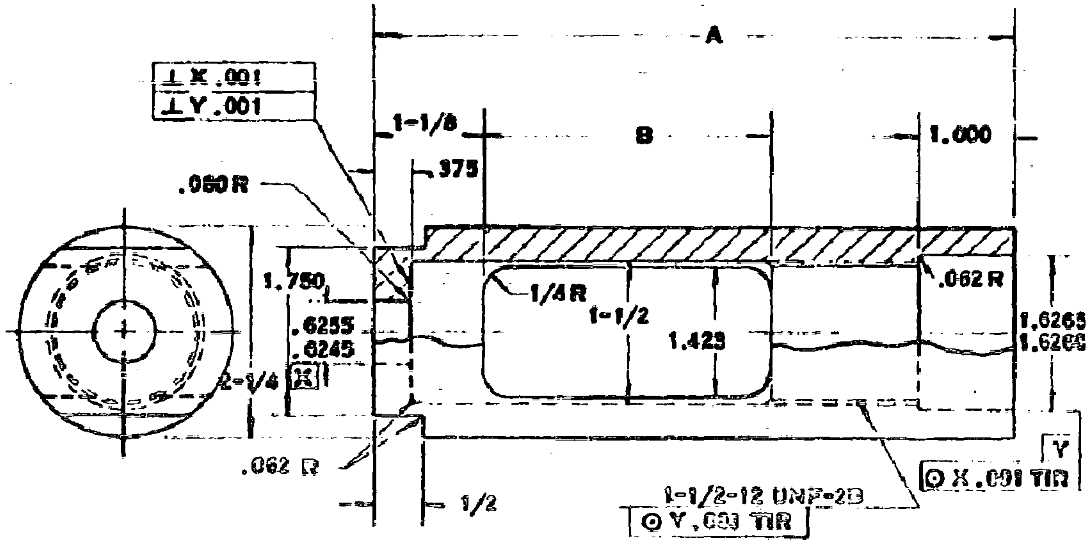
A
5/8-18 NF
3/4-10 NC
3/4-16 NF
7/8-9 NC
7/8-14 NF
1-8 NC
1-14 NF

NOTES:

1. RADIUS TO BE COLD WORKED AFTER HEAT TREAT
2. THREADS TO BE CLASS 3B
3. TOLERANCES UNLESS SPECIFIED: FRACTIONS ± 1/64, DECIMALS ±.010
   ANGLES ± 2°
4. SURFACE FINISH: 60 RMS
5. MATERIAL, 40 CARBON STEEL
6. HEAT TREAT, 33-38 R_c

FIGURE 56

Threaded Adapter 15,000 and 60,000 Pound Fatigue Link



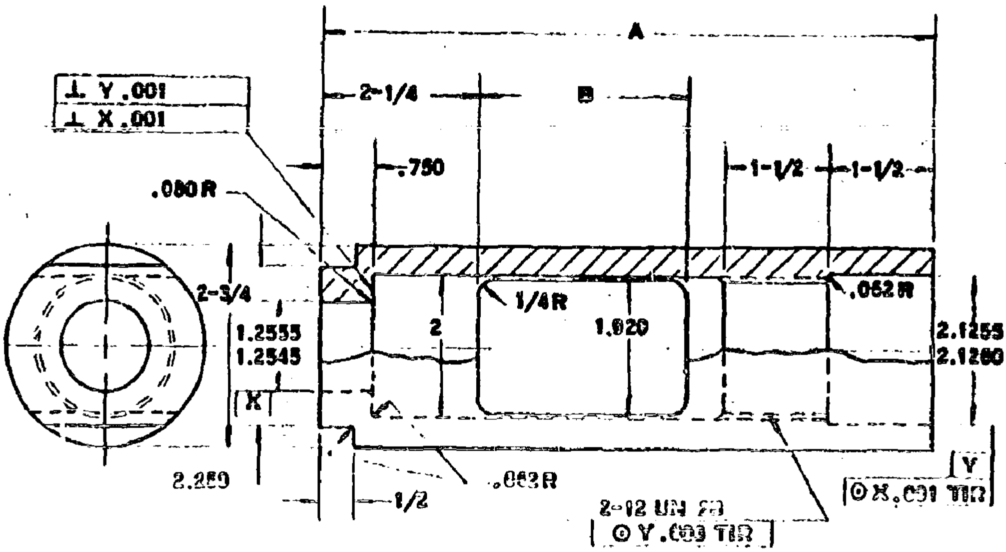
	A	B
TOP LINK	6-5/8	5
BOTTOM LINK	6-5/8	3

NOTES:

1. ALL RADII SHALL BE A SMOOTH BLEND.
2. TOLERANCE UNLESS SPECIFIED;
   FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±2°.
3. MATERIAL: 40 CARBON ALLOY STEEL.
4. HEAT TREAT: 32-35 R_c.

FIGURE 57

5,000 to 15,000 Pound Tension Fatigue Adapter



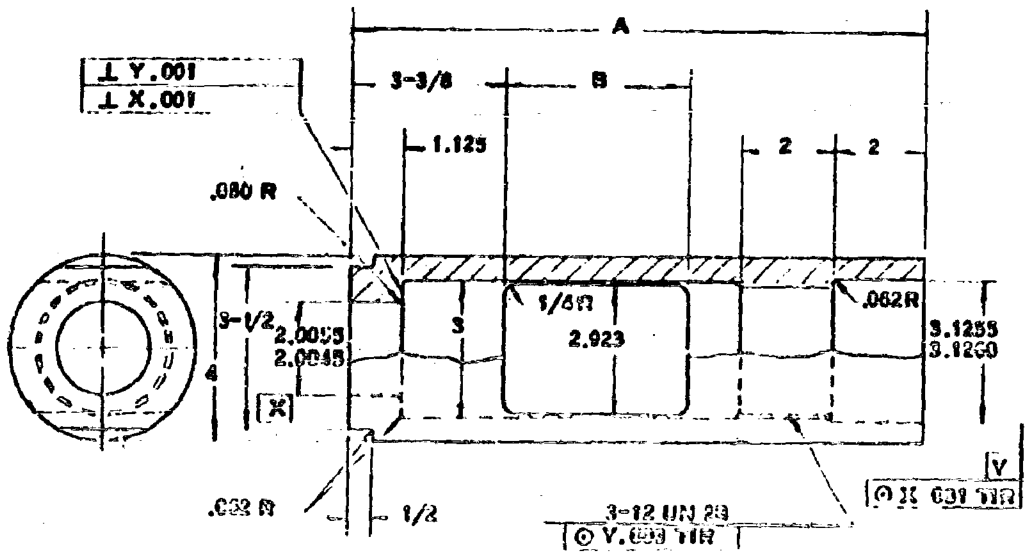
	A	B
TOP LINK	12-1/4	8
BOTTOM LINK	6-3/4	3

NOTES:

1. ALL RADII MUST BE A SMOOTH BLEND.
2. TOLERANCE UNLESS SPECIFIED:
   FRACTIONS ±1/64, DECIMALS ±.005
3. MATERIAL: 40 CARBON ALLOY STEEL
4. HEAT TREAT: 32-35 R_c.

FIGURE 58

25,000 to 60,000 Pound Tension Fatigue Adapter



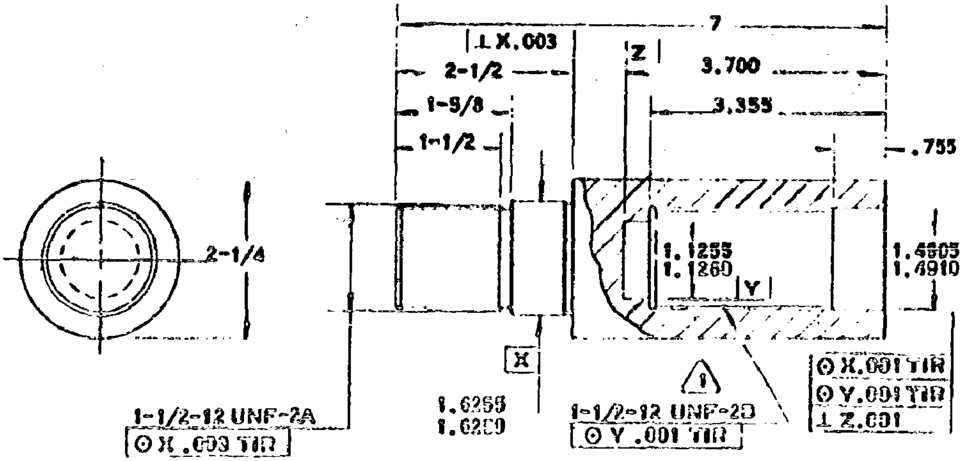
	A	B
TOP LINK	16-1/2	10
BOTTOM LINK	12-1/2	4

NOTES:

1. ALL RADII SHALL BE A SMOOTH BLEND.
2. TOLERANCE UNLESS SPECIFIED:
   FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±2°.
3. MATERIAL: 40 CARBON ALLOY STEEL.
4. HEAT TREAT: 32-35 R_c.

FIGURE 59

60,000 to 200,000 Pound Tension Fatigue Adapter

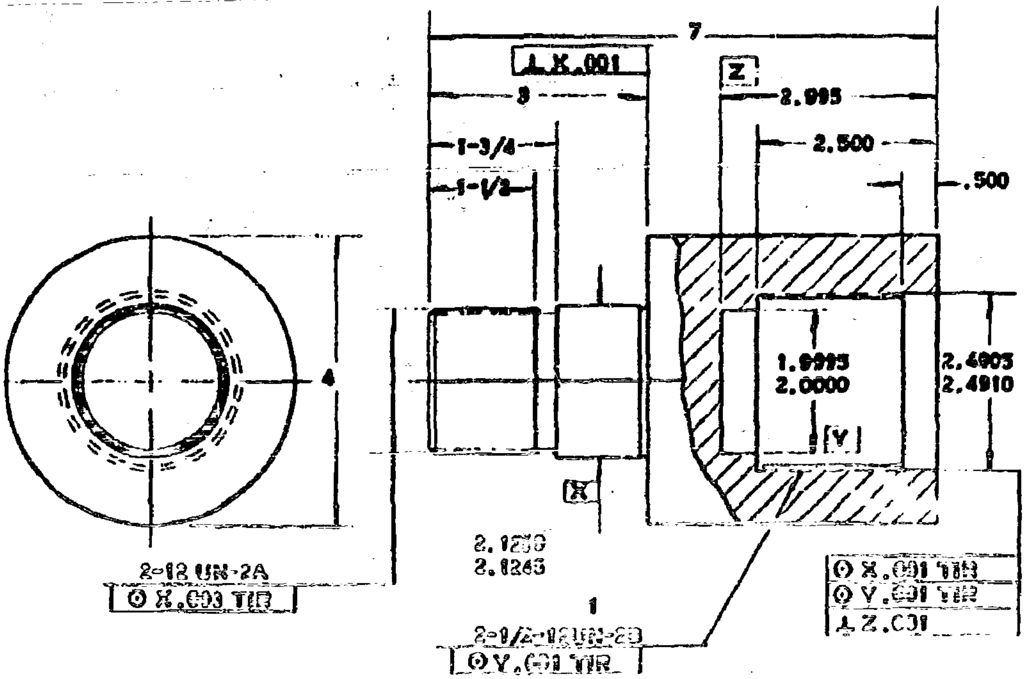


NOTES:

1. MAJOR DIA. OF THREAD TO BE ADJUSTED TO SUIT MATING THREAD.
2. TOLERANCE UNLESS SPECIFIED: FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ± 2°.
3. CHAMFER ALL SHARP CORNERS.
4. MATERIAL: 40 CARBON ALLOY STEEL.
5. HEAT TREAT: 40-45 R_c

FIGURE 60

15,000 Pound Adapter Krouse Machine



NOTES:

1. MAJOR DIA. OF THREAD TO BE ADJUSTED TO SUIT MATING THREAD.
2. TOLERANCE UNLESS SPECIFIED:
   FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±2°.
3. MATERIAL: 40 CARBON ALLOY STEEL.
4. HEAT TREAT: 40-45 R_c.

FIGURE 61

60,000 Pound Adapter Krouse Machine

FIGURE 62

Close up of Fatigue Failure of NAI-160 Fatigue Link
200,000# Capacity

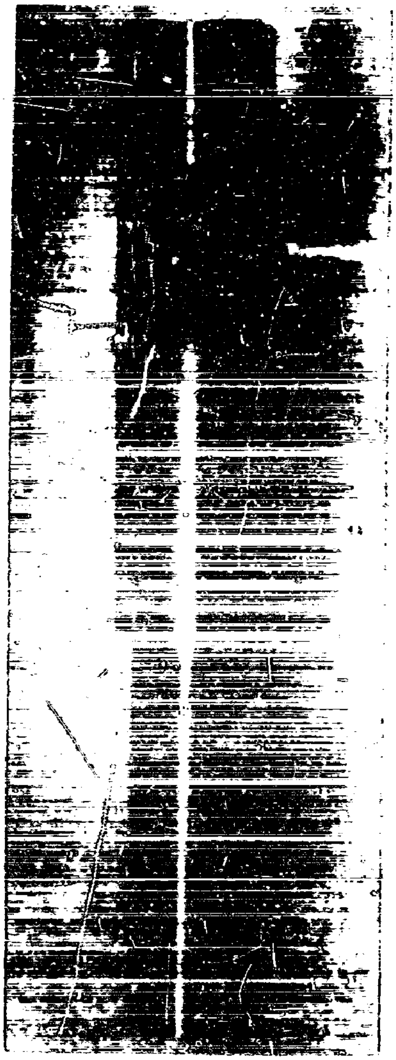


FIGURE 63

Full View of NAI-160 Fatigue Link
Failure is Noticeable in Upper Part

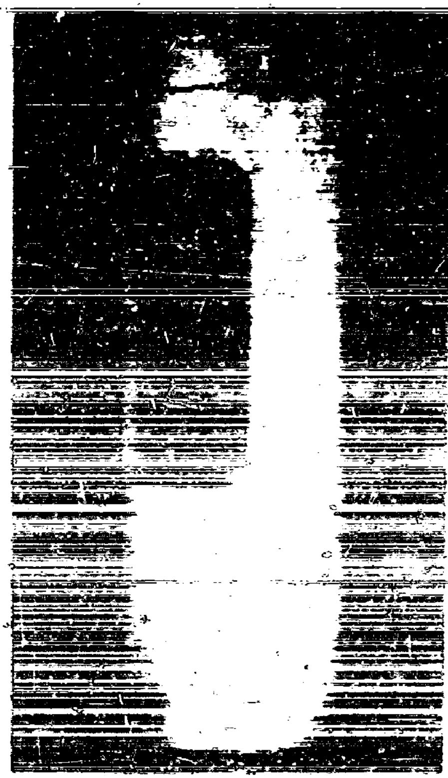
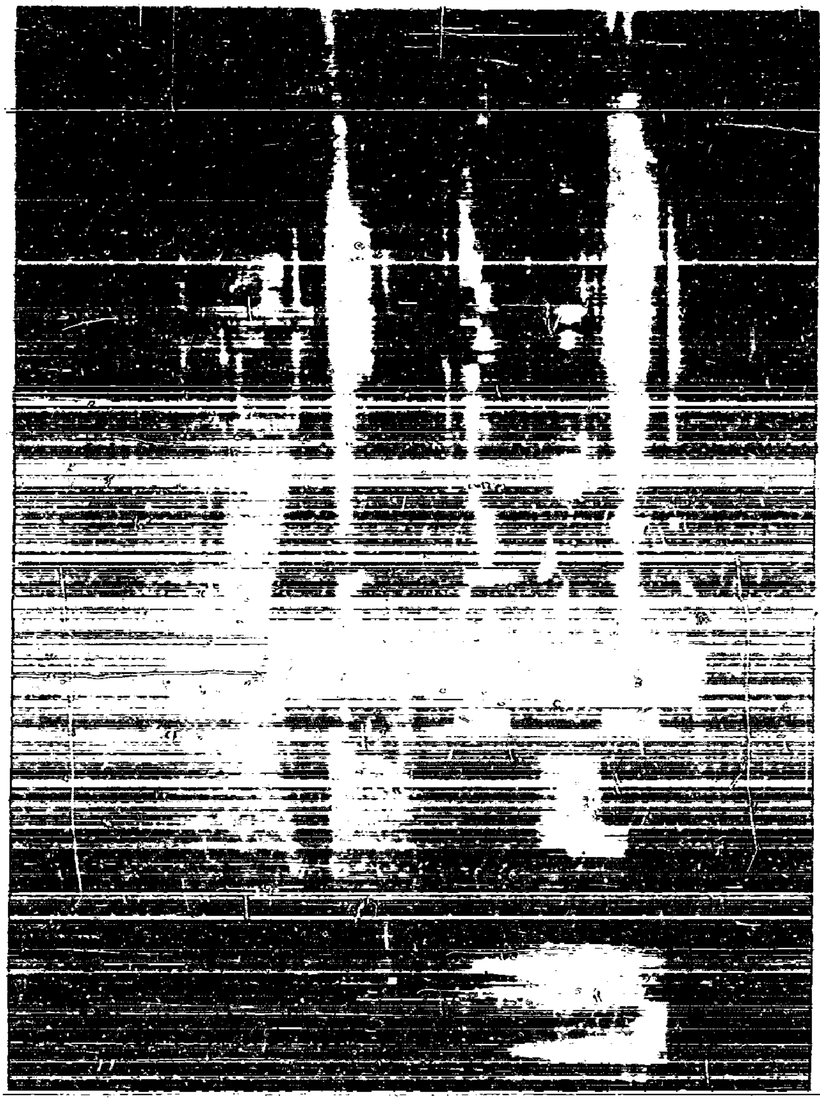


FIGURE 64

Fatigue Failure of NAI 160, 15,000 Pound Link



Location of Strain Gages on Flexure Plates

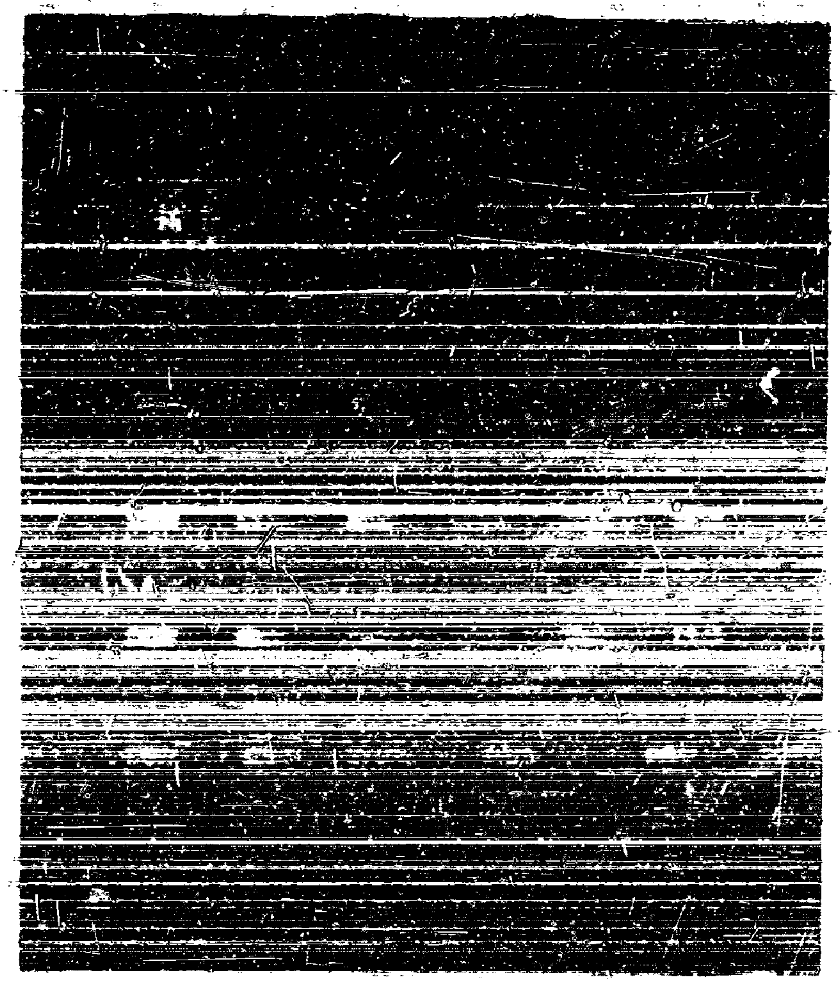
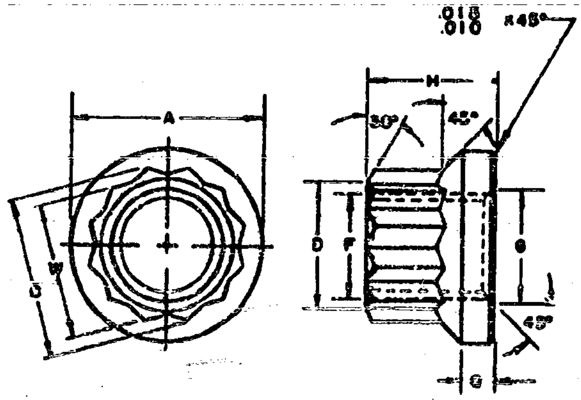


FIGURE 66

Instrumentation used on each Fatigue Machine
To Measure Dynamic Loads

FIGURE 67

Oscillograph Pattern of Dynamic Load and Measuring Circuit



SIZE	A +.[illegible] −.010	C MIN	D +.[illegible] −.010	F +.005 −.010	G +.010 −.000	H ±.005	Q ±.005	W MAX	W MIN
1/4-28	.531	.410	.373	.303	.301	.344	.[illegible]	.578	.557
5/16-24	.[illegible]	.491	.453	.[illegible]	.[illegible]	.[illegible]	.[illegible]	.659	.[illegible]
3/8-24	.[illegible]	.551	.503	.[illegible]	.[illegible]	.433	.124	.[illegible]	.[illegible]
7/16-20	.781	.631	.[illegible]	.453	.[illegible]	.516	.112	.[illegible]	.553
1/2-20	.875	.705	.[illegible]	.515	.[illegible]	.550	.120	.[illegible]	.616
9/16-18	.[illegible]	.773	.[illegible]	.570	.[illegible]	.[illegible]	.[illegible]	.[illegible]	.[illegible]
5/8-18	1.[illegible]	.[illegible]	.781	.[illegible]	.[illegible]	.672	.[illegible]	.[illegible]	.771
3/4-16	1.[illegible]	1.[illegible]	.[illegible]	.[illegible]	.781	.781	.[illegible]	.[illegible]	.[illegible]
7/8-14	1.433	1.[illegible]	1.[illegible]	.[illegible]	.[illegible]	.[illegible]	.219	1.[illegible]	1.[illegible]
1"-14	1.[illegible]	1.[illegible]	1.[illegible]	1.018	1.[illegible]	1.[illegible]	.[illegible]	1.[illegible]	1.[illegible]
1-1/8-12	1.[illegible]	1.557	1.378	1.143	1.158	1.[illegible]	.[illegible]	1.577	1.[illegible]
1-1/4-12	2.123	1.[illegible]	1.[illegible]	1.[illegible]	1.231	1.[illegible]	.320	1.502	1.480
1-3/8-12	2.313	1.642	1.625	1.[illegible]	1.406	1.[illegible]	.350	1.637	1.616
1-1/2-12	2.500	2.056	1.813	1.515	1.531	1.625	.375	1.814	1.800

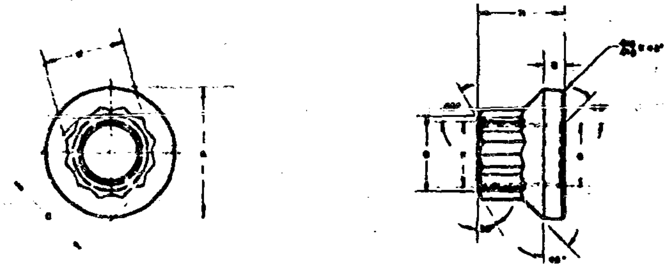
NOTES:

1. BEARING SURFACES MUST BE SQUARE WITH PITCH DIAMETER WITHIN .003 TIR.
2. ALL THREADS TO BE CLASS 3B.
3. TAP THREADS AFTER HEAT TREAT.
4. ~~APPLY RUST PREVENTING OIL.~~
5. MATERIAL: 8630AQ – 8740AQ

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED,
TOLERANCES, DECIMALS ±.010, ANGLES ±2°

FIGURE 68

Fatigue Test Nuts for Tension Bolts under 200,000 PSI Ultimate



THREAD	A DIA	C MIN	D DIA	F DIA	G DIA	H	J	U	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						

NOTES:

1. BEARING SURFACE MUST BE SQUARE WITH PITCH DIAMETER WITHIN [illegible] T.I.R.
2. ALL THREADS TO BE CLASS [illegible].
3. TAP THREADS AFTER HEAT TREAT.
4. APPLY RUST PREVENTING OIL.
5. MATERIAL: ALLOY STEEL, AMS [illegible], AMS [illegible]

[illegible] UNLESS OTHERWISE SPECIFIED, TOLERANCES, DECIMALS [illegible] ANGLES [illegible]

FIGURE 69

Fatigue Test Nuts for Tension Bolts under 240,000 PSI Ultimate

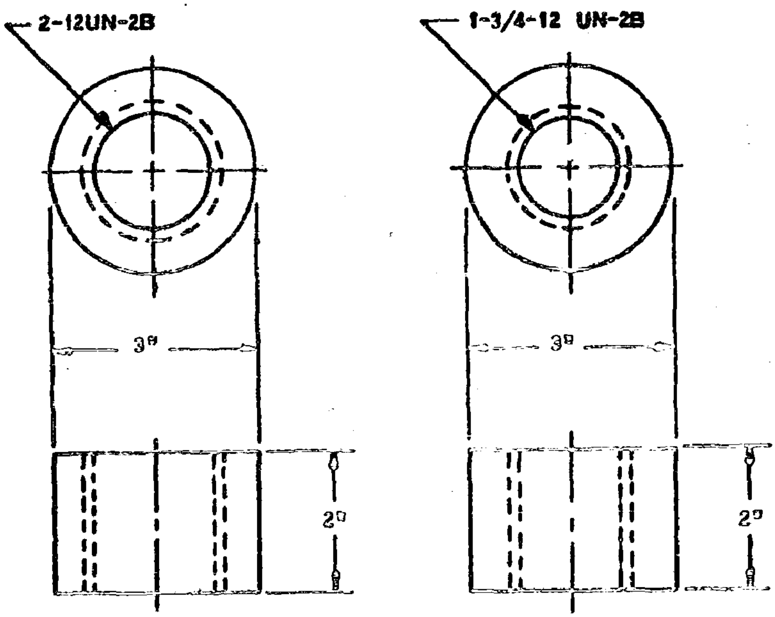
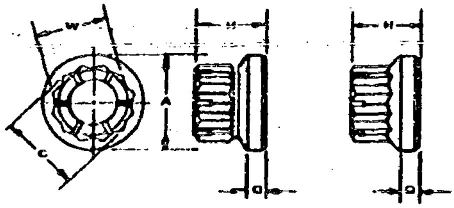


FIGURE 61.

SPECIAL NUTS FOR STUDS

FIGURE 70

Special Nuts for Studs

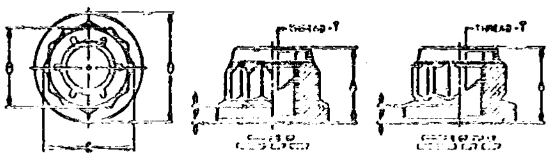


STYLE	PART NO.	THREAD	A DIA.	C (MIN)	H	G	W	TENSILE STRENGTH	APPROX. WT. PER 1,000 PIECES IN LBS.
A	[illegible]	1/4-28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	5/16-24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	3/8-24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	7/16-20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	1/2-20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	9/16-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	5/8-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	[illegible]	3/4-16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	7/8-14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	1-14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	1-1/8-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	1-1/4-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	1-3/8-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	1-1/2-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CADMIUM PLATE PER SPS-P-2A
THREADS TO BE CLASS NF-3 PER MIL-S-7742
MATERIAL: AMS 6320 MIN.

FIGURE 71
FLEXLOC Self-locking External Wrenching Nut
for use with 180,000 psi Minimum Bolts

ELASTIC STOP NUT CORPORATION OF AMERICA, UNION, NEW JERSEY



[illegible]	THREAD T	A	D	C	D	F	ULTIMATE TENSILE [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	.69	[illegible]	[illegible]	7,1[illegible]	[illegible]	•
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,[illegible]	[illegible]	•
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•
[illegible]	7/8-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•
[illegible]	1-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•
[illegible]	1 1/8-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
[illegible]	1 1/4-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
[illegible]	1 3/8-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6
[illegible]	1 1/2-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6

CODE: PART NUMBER DESIGNATES DOUBLE HEX HIGH TENSILE NUT AS SPECIFIED IN TABULATION ABOVE.

EXAMPLE: [illegible] = DOUBLE HEX, HIGH TENSILE NUT, [illegible]

MATERIAL: [illegible]

FINISH: CADMIUM PLATE - FEDERAL SPEC QQ-P-416, TYPE I, CLASS C.

[illegible]

[illegible]

MAGNETIC PARTICLE INSPECTION: PARTS [illegible] INSPECTED IN ACCORDANCE WITH MILITARY SPECIFICATION [illegible]

ESNA - STANDARD

NAS[illegible] AS APPLICABLE

NUT - DOUBLE HEX, HIGH TENSILE

EB

WADC TR 59-526

106

FIGURE 72

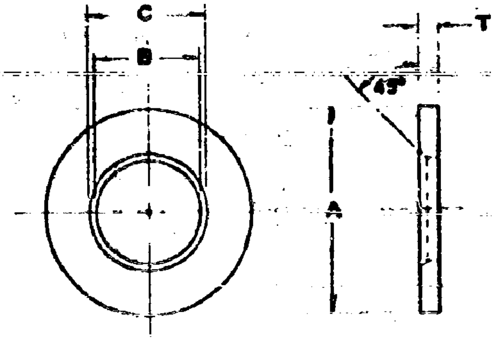
ELASTIC STOP NUT CORPORATION OF AMERICA, UNION, NEW JERSEY

[illegible]

ESNA - STANDARD

NUT - DOUBLE HEX, HIGH TENSILE

EB



COUNTERSUNK WASHER

PART (5)	SIZE	A ±.03	B MAX	B MIN	C ±.[illegible]	T MAX	T MIN
WC22-4	1/4	.601	.255	.231	.339	.059	.058
WC22-5	5/16	.610	.310	.314	.401	.053	.039
WC22-6	3/8	.750	.380	.376	.480	.039	.069
WC22-7	7/16	.673	.443	.439	.530	.039	.039
WC22-8	1/2	1.033	.505	.501	.612	.033	.039
WC22-9	9/16	1.130	.563	.564	.677	.039	.039
WC22-10	5/8	1.233	.631	.627	.775	.053	.053
WC22-12	3/4	1.320	.755	.752	.850	.053	.053
WC22-14	7/8	1.750	.881	.877	1.033	.119	.039
WC22-16	1"	[illegible]	1.005	1.003	1.150	.119	.039
WC22-18	1-1/8	2.235	1.131	1.127	1.275	.119	.039
WC22-20	1-1/4	2.505	1.255	1.252	1.437	.119	.059
WC22-22	1-3/8	2.620	1.381	1.377	1.562	.119	.039
WC22-24	1-1/2	3.100	1.505	1.502	1.687	.119	.039

NOTES:

1. CODE:
   DASH NUMBER DESIGNATES BOLT DIAMETER IN SIXTEENTHS.
2. MATERIAL: ALLOY STEEL MIL-S-6758 OR MIL-S-18729
3. APPLY RUST PREVENTING OIL.
4. MAGNAFLUX 100 % PER MIL-I-6868
5. WASHER FACES MUST BE PARALLEL WITHIN .002 INCH
6. DIMENSIONS IN INCHES, UNLESS OTHERWISE SPECIFIED.
   TOLERANCES: DECIMALS ±.010, ANGLES ± 2°.

FIGURE 73

SPS WC 22 Washers

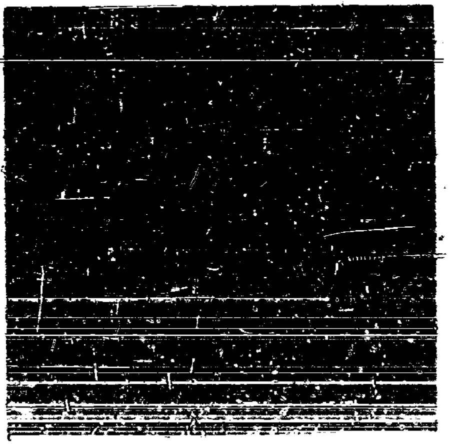


FIGURE 74

Fatigue Fracture Resulting From Bending

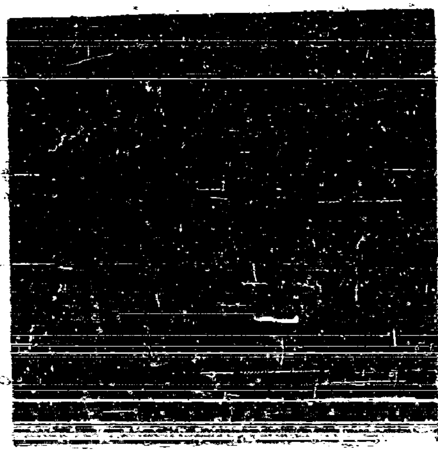


FIGURE 75

Fatigue Fracture Resulting From Uniaxial Loading

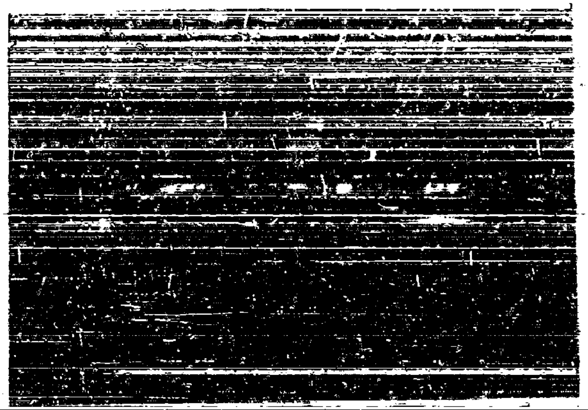


FIGURE 76

Bolt Body Showing Rubbing Marks Resulting From Non-Axial Loading

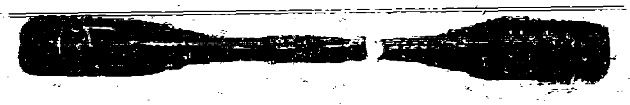


FIGURE 77

Fatigue Fracture in Shank of 3/4 inch Test Specimen

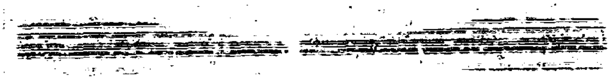


FIGURE 78

Fatigue Fracture in Thread Section of 3/4 inch Test Specimen Resulting from Shot Peening of Radius

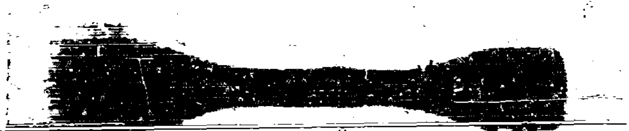


FIGURE 79

Fatigue Fracture in 2-12 Cut Thread Rather than 1-14 Rolled Thread

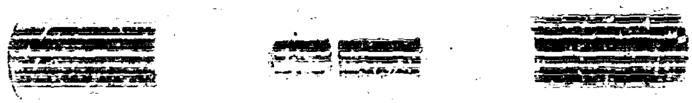
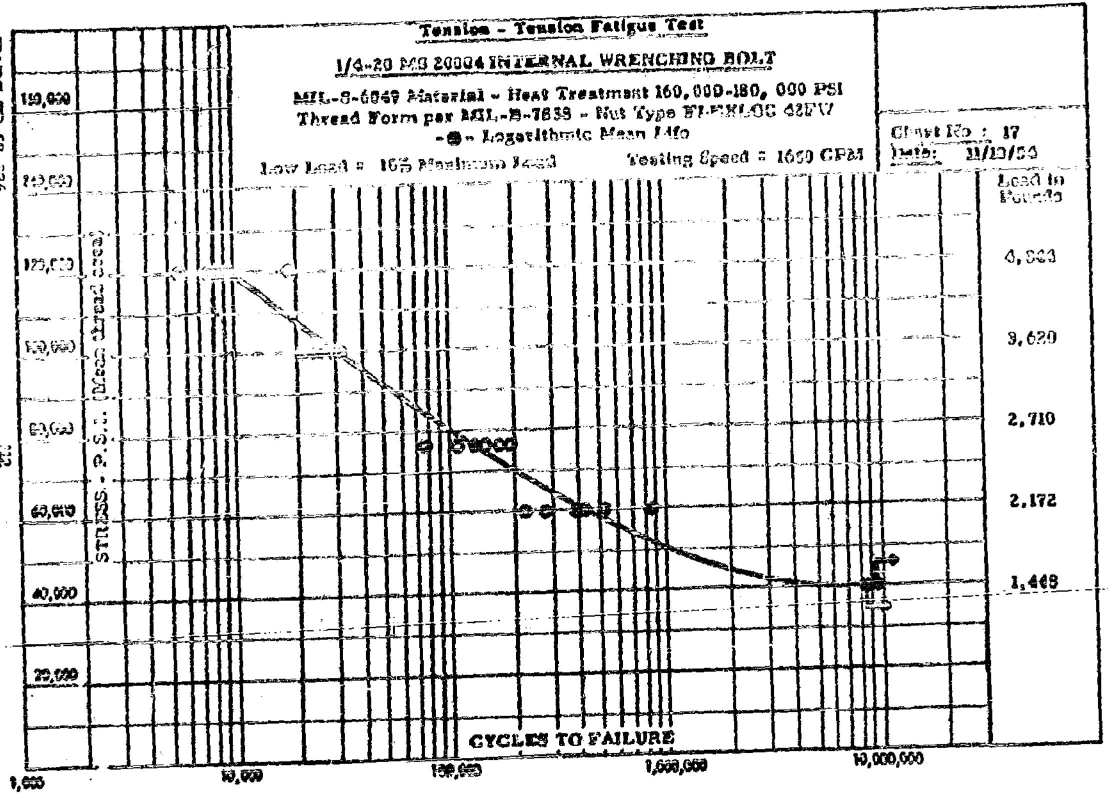


FIGURE 60

Typical Fatigue Fracture of Cut and Ground Unengaged Threads

APPENDIX I

RAW DATA FOR 160,000 PSI PARTS



Tension - Tension Fatigue Test
1/4-20 MS 20004 INTERNAL WRENCHING BOLT
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838 - Nut Type ELASTIC STOP NUT
-●- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1650 CPM
Chart No.: 17
Date: 11/13/54
Load in Pounds
4,344
3,620
2,710
2,172
1,448
40,000
20,000
STRESS - P.S.I. (Mean thread area)
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 11-18-54

Bolt Design	MS 20004
Size	1/4-28
Material	MIL-S-6049
Heat Treatment	160,000-180,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium plate per QQ-P-416 Type I, Class C
Stress Area	.0362 Square Inches
Nut Type	
Style	42FW
Material	AISI 8630
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	5,000 pound
Speed	1650 cpm

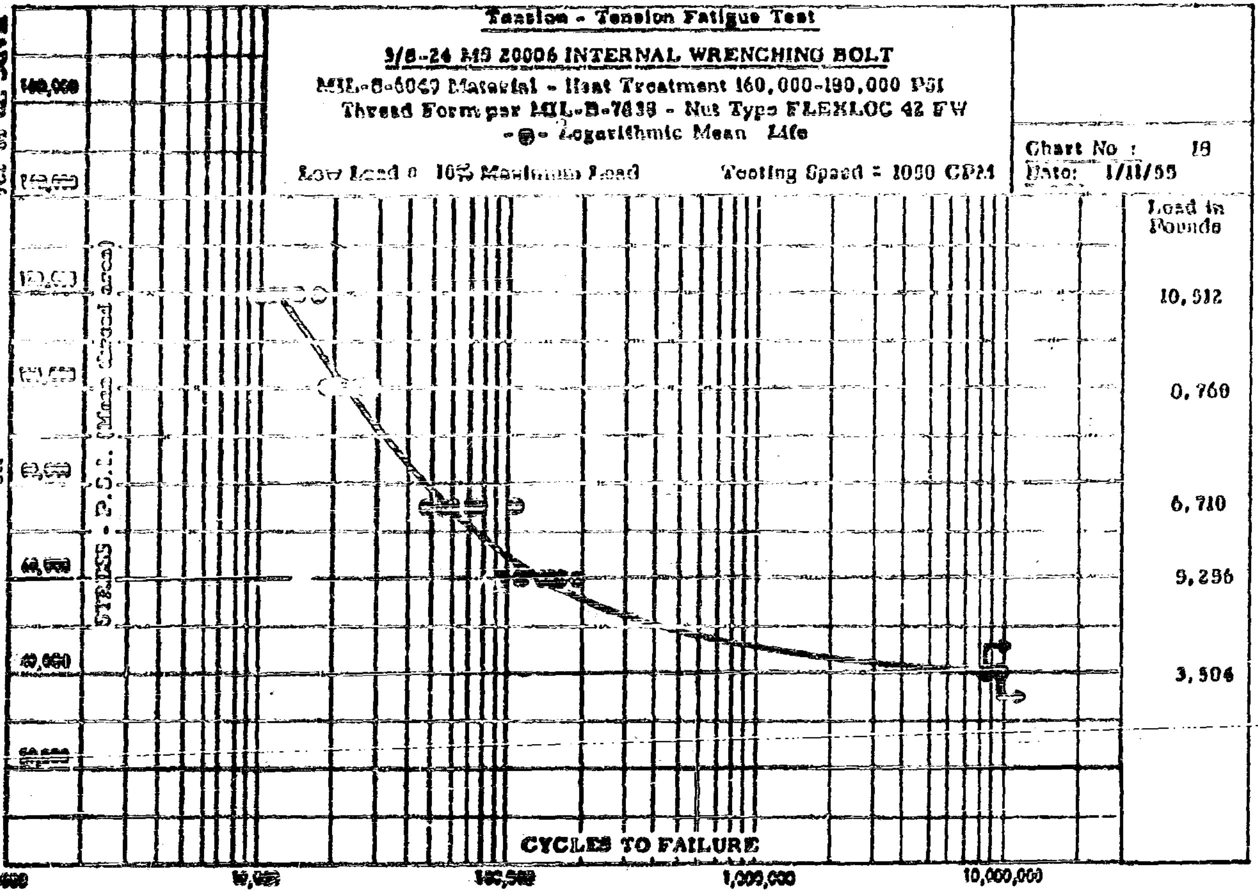
Maximum Load	4,344#	3,620#	2,896#
Stress	120,000 psi	100,000 psi	80,000 psi
	19,500	29,100	80,400
	9,100	28,000	87,000
	8,600	25,600	76,400
	7,900	23,400	73,100
	6,700	22,300	
Average	10,360	25,680	
Logarithmic Mean Life	9,582	25,550	

Maximum Load	2,710#	2,172#	1,448#
Stress	77,000 (MIL-B)	60,000 psi	40,000 psi
	199,200	833,200	8,477,000 NF
	163,000	525,200	8,951,000 NF
	104,200	427,300	
	77,800	277,900	
		222,100	
Average	136,000	455,120	8,714,000
Logarithmic Mean Life	128,500	409,700	

MECHANICAL PROPERTIES

Date November 18, 1954 For Chart No. 17

Bolt Description		
Type	MS 20004	
Size	1/4-28	
Material	MIL-S-6049	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile	6,660	6,780
Yield Strength	5,500	5,600
Material Strength PSI		
Gage Specimen		
Tensile Strength	159,000	165,000
Yield Strength	149,500	150,500
Elongation - % in 4 Diameter		
Gage Specimen	12.5	12.5
Reduction of Area - %		
Gage Specimen	51.3	53.7
Shear Strength - Bolt Body		
Pounds - Double Shear	10,400	10,080
PSI	105,900	110,000
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	1,448	
PSI (Mean Area)	40,000	
Lot No.	6S4144E	


Tension - Tension Fatigue Test
3/8-24 MS 20006 INTERNAL WRENCHING BOLT
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838 - Nut Type FLEXLOC 42 FW
-⊕- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No : 19
Date: 1/11/55
Load in Pounds
10,512
0,760
6,710
9,256
3,504
STRESS - P.S.I. (Mean thread area)
140,000
60,000
40,000
CYCLES TO FAILURE
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 1-6-58

Bolt Design	MS 20006
Size	3/8-24
Material	MIL-S-6049
Heat Treatment	160,000-180,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium Plate per QQ-P-416 Type I, Class C
Stress Area	.0876 Square inches
Nut Type	
Style	62FW
Material	AISI 8630
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	15,000 pounds
Speed	1050 cpm

Maximum Load	10,512#	8,760#	6,710#
Stress	120,000 psi	100,000 psi	MIL-B
	11,000	21,400	72,000
	11,500	20,500	107,000
	10,000	20,500	69,000
	11,400	21,400	71,800
	17,000	20,800	69,600
Average	12,180	20,920	77,880
Logarithmic Mean Life	11,960	20,915	76,710

Maximum Load	5,256#	3,504#
Stress	60,000 psi	40,000 psi
	163,000	10,373,500
	93,400	9,442,200
	126,000	
	190,900	
	129,700	
Average	140,740	9,907,850
Logarithmic Mean Life	136,050	8,000,000

MECHANICAL PROPERTIES

Date January 11, 1955 For Chart No. 18

Bolt Description

Type	MS 20006
Size	3/8-24
Material	MIL-S-6049

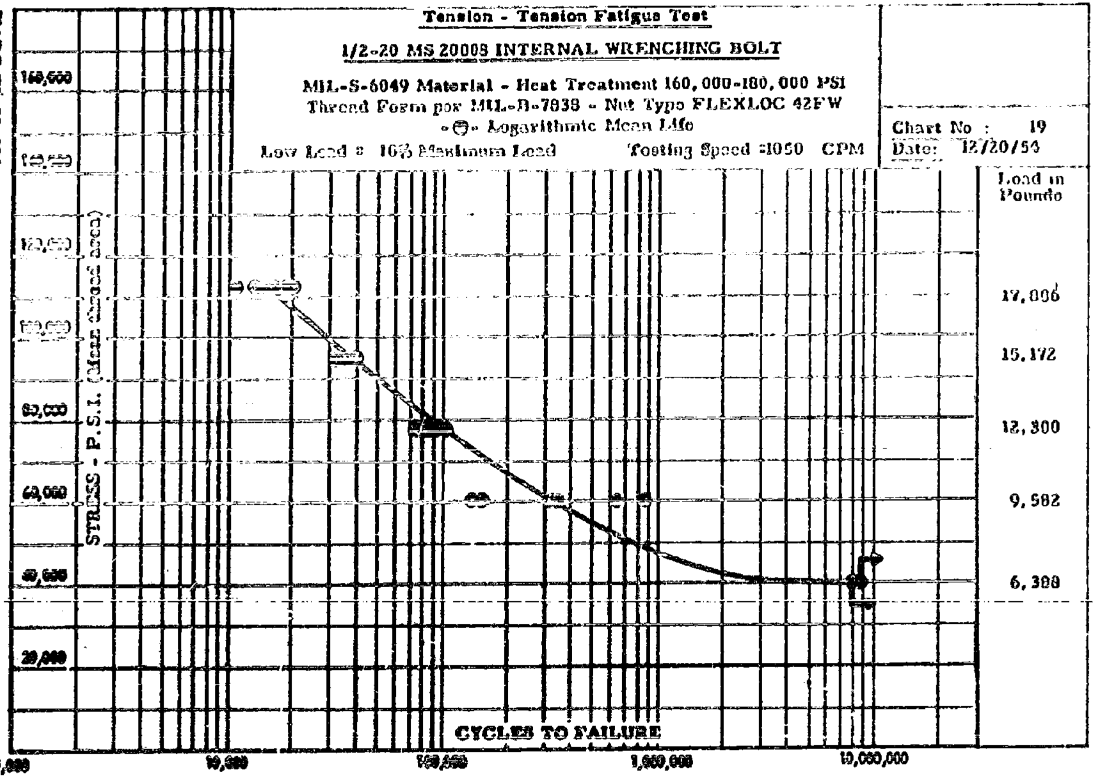
Bolt Strength Pounds

	Specimen 1	Specimen 2
Ultimate Tensile	15,000	15,400
Yield Strength	12,600	12,600
Material Strength PSI		
.252Gage Specimen		
Tensile Strength	171,300	168,700
Yield Strength	149,200	147,000
Elongation - % in 4 Diameter		
.252Gage Specimen	14.4	14.6
Reduction of Area - %		
.252Gage Specimen	52.4	52.4
Shear Strength - Bolt Body		
Pounds - Double Shear	22,000	22,500
PSI	99,600	101,900

Fatigue Strength @ 8,000,000 Cycles 10% Low Load

Pounds	3,504
PSI (Mean Area)	40,000

Lot No. 12264K47K


Tension - Tension Fatigue Test
1/2-20 MS 20008 INTERNAL WRENCHING BOLT
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838 - Nut Type FLEXLOC 42FW
Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed =1050 CPM
Chart No : 19
Date: 12/20/54
Load in Pounds
17,006
15,172
12,300
9,582
6,388
STRESS - P.S.I. (Mean thread area)
160,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 12-20-54

Bolt Design	MS 20008
Size	1/2-20
Material	MIL-S-6049
Heat Treatment	160,000-180,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium Plate per QQ-P-416 Type I, Class C
Stress Area	.1597 Square inches
Nut Type	
Style	42 FW
Material	AISI 6200
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1050 cpm

Maximum Load	17,086#	15,172#	12,300#
Stress	111,700 psi	93,050 psi	MIL-B
	19,700	39,500	103,000
	18,000	37,600	90,000
	15,000	37,000	86,500
	12,900	36,500	84,600
	10,440	35,000	72,000
Average	15,440	37,120	87,220
Logarithmic Mean Life	15,057	37,090	86,642

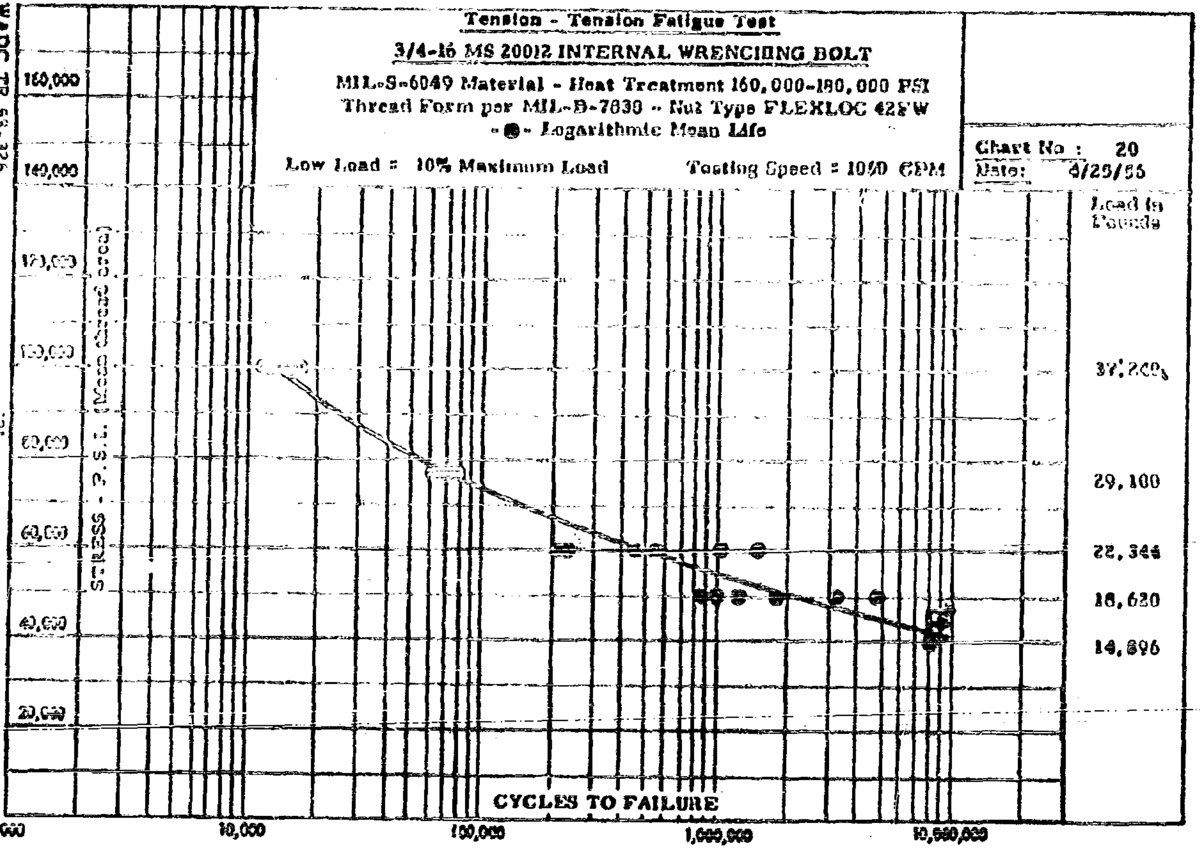
Maximum Load	9,582#	6,388#
Stress	60,000 psi	40,000 psi
	813,600	8,000,000 NF
	645,200	8,982,600 NF
	331,800	
	131,900	
	130,000	
Average	390,500	8,491,300
Logarithmic Mean Life	113,720	

MECHANICAL PROPERTIES

Date December 20, 1954 For Chart No. 19

Bolt Description

Type	MS 20008	
Size	1/2-20	
Material	MIL-S-6049	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile	29,300	31,000
Yield Strength	25,000	26,000
Material Strength PSI		
.357 Gage Specimen		
Tensile Strength	172,700	176,100
Yield Strength	157,000	159,600
Elongation - % in 4 Diameter		
.357 Gage Specimen	14.8	16.4
Reduction of Area - %		
.357 Gage Specimen	56.2	60.0
Shear Strength - Bolt Body		
Pounds - Double Shear	41,690	41,750
PSI	105,900	106,000
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	6,388	
PSI (Mean Area)	40,000	
Lot No.	1IS4M48A	


Tension - Tension Fatigue Test
3/4-16 MS 20012 INTERNAL WRENCHING BOLT
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838 - Nut Type FLEXLOC 428W
-●- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1000 CPM
Chart No: 20
Date: 4/25/55
Load in Pounds
37,200
29,100
22,344
18,620
14,896
STRESS - P.S.I. (Mean thread area)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
1,000
10,000
100,000
1,000,000
10,000,000
CYCLES TO FAILURE

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 4-25-57

Bolt Design	MS 20012
Size	3/4-16
Material	MIL-S-6049
Heat Treatment	160,000-180,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium plate per QQ-P-416 Type I, Class C
Stress Area	0.3724 Square inches
Nut Type	
Style	42FW
Material	AISI 8740
Heat Treatment	Rc 30-34
Testing Machine	
Make	Krouse
Capacity	60,000 pound
Speed	850 cpm

Maximum Load	37,240#	29,100#	22,344#
Stress	100,000 psi	MIL-B	60,000 psi
	15,200	76,100	1,532,000
	15,100	75,400	1,067,700
	14,200	75,400	467,700
	13,700	62,600	213,000
	12,600	61,800	206,300
Average	14,160	70,260	697,300
Logarithmic Mean Life	14,130	69,900	507,200

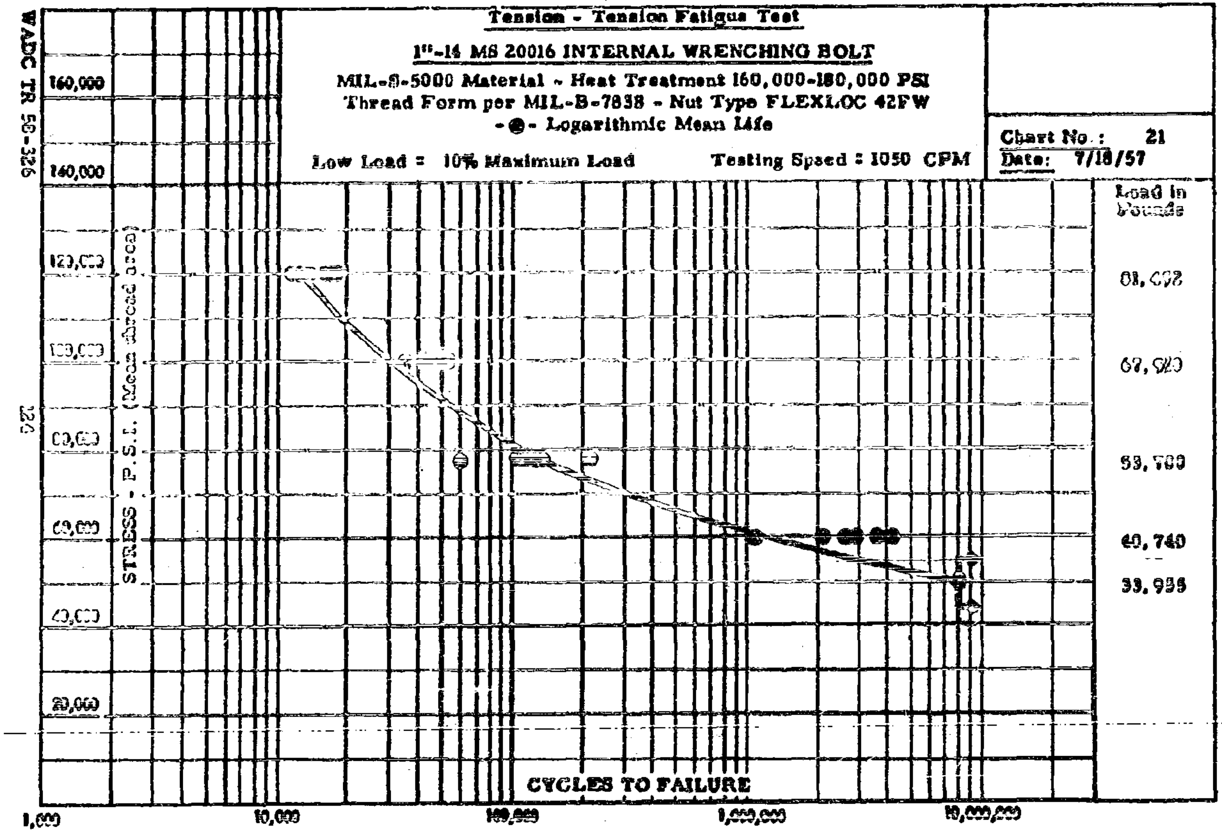
Maximum Load	18,620#	14,896#
Stress	50,000 psi	40,000 psi
	1,214,600	8,746,000 NF
	3,106,300	8,681,500 NF
	4,872,100	
	983,000	
	849,700	
Average	2,205,140	8,713,700
Logarithmic Mean Life	1,728,000	

MECHANICAL PROPERTIES

Date March 28, 1955 For Chart No. 20

Bolt Description

Type	MS 20012	
Size	3/4-16	
Material	MIL-S-6049	
Bolt Strength Pounds	**Specimen 1**	**Specimen 2**
Ultimate Tensile	70,600	72,600
Yield Strength	60,000	62,000
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	177,700	177,700
Yield Strength	162,800	162,800
Elongation % in 4 Diameter		
.505 Gage Specimen	14.7	13.9
Reduction of Area - %		
Gage Specimen	43.0	44.2
Shear Strength - Bolt Body		
Pounds - Double Shear	92,000	95,300
PSI	103,100	107,900
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	14,895	
PSI (Mean Area)	40,000	
Lot No.	216S94P72	


Tension - Tension Fatigue Test
1"-14 MS 20016 INTERNAL WRENCHING BOLT
MIL-S-5000 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838 - Nut Type FLEXLOC 42FW
-●- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed : 1050 CPM
Chart No.: 21
Date: 7/18/57
Load in Pounds
40,740
STRESS - P.S.I. (Mean thread area)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

~~10% Preload - Stress Calculated on Tensile Stress Area~~

Date: 7-18-57

Bolt Design	MS 20016
Size	1-14
Material	MIL-S-5000
Heat Treatment	160,000-180,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium Plate per QQ-P-416 Type I, Class C
Stress Area	0.6791 Square inches
Nut Type	
Style	42 FW
Material	AISI 0740
Heat Treatment	Rc 30-34
Testing Machine	
Make	Amsler
Capacity	220,000 pound
Speed	500 cpm

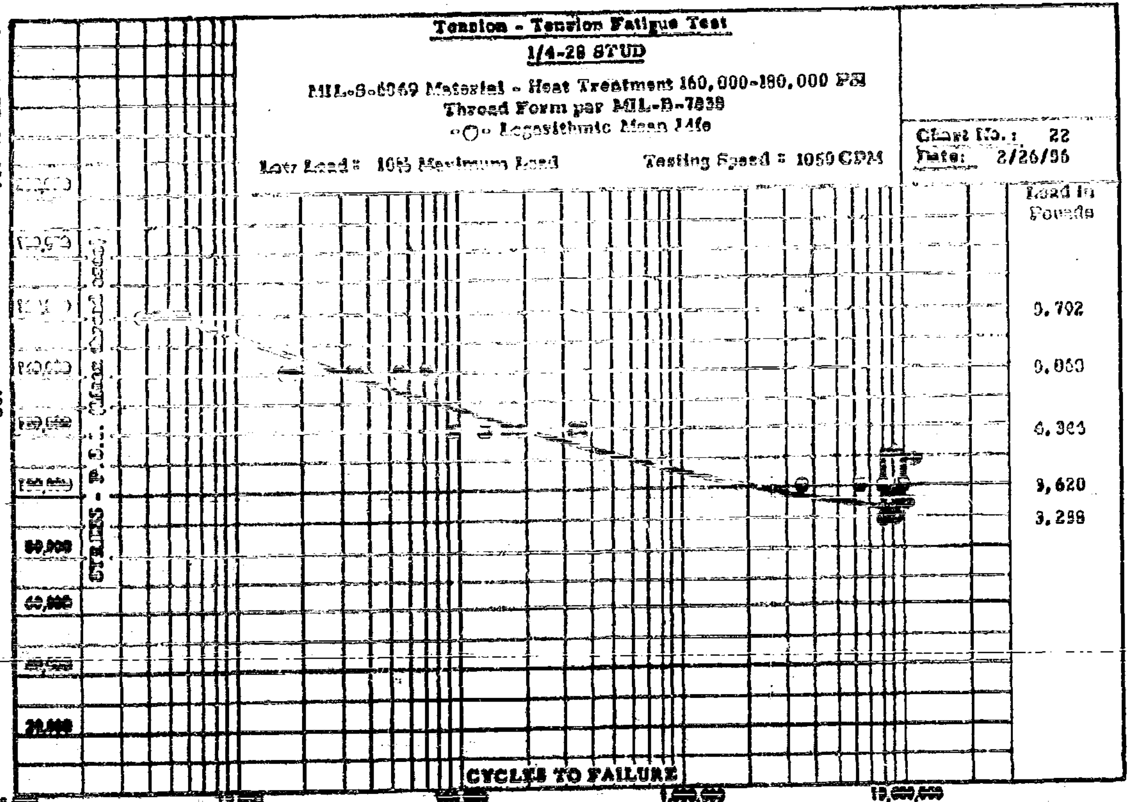
Maximum Load	01,4920	67,9100	53,7000
Stress	120,000 psi	100,000 psi	MIL-B
	12,400	35,000	60,000
	13,000	42,300	105,500
	16,200	43,900	131,300
	16,900	44,800	132,300
	18,100	51,300	212,000
Average	15,300	43,460	128,200
Logarithmic Mean Life	15,160	42,740	118,400

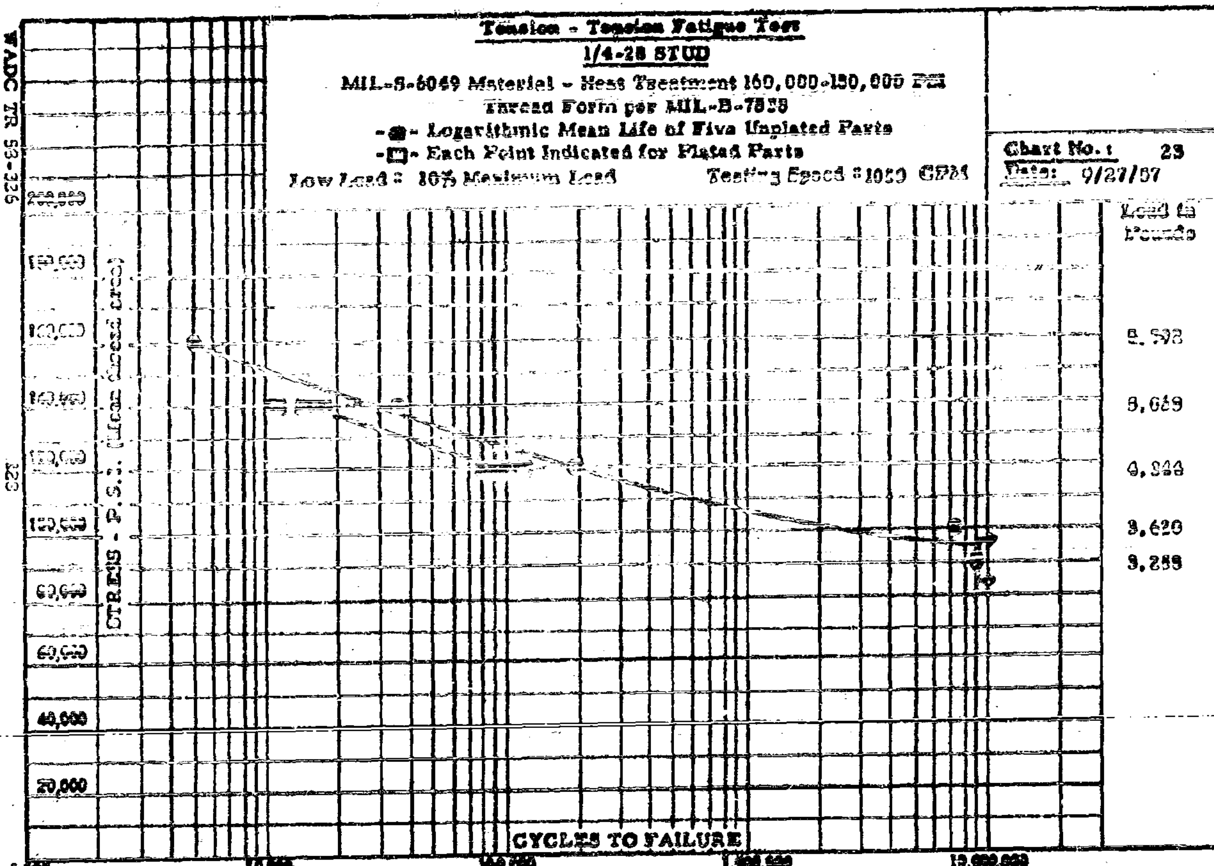
Maximum Load	40,7408	33,9558
Stress	60,000 psi	50,000 psi
	1,076,800	8,000,000
	2,276,000	8,000,000
	2,831,000	
	3,665,000	
	4,190,000	
Average	2,807,700	8,000,000
Logarithmic Mean Life	2,544,000	8,000,000

MECHANICAL PROPERTIES

Date July 24, 1957 **For Chart No.** 21

Bolt Description		
Type	MS 20016	
Size	1"-14	
Material	MIL-S-5000	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile	126,000	127,000
Yield Strength	115,000	117,000
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	32,500	34,000
Yield Strength	31,250	32,750
Elongation % in 4 Diameter		
.505 Gage Specimen	10.0	10.0
Reduction of Area - %		
.505 Gage Specimen	54.9	52.0
Shear Strength - Bolt Body		
Pounds - Double Shear	156,000	156,000
PSI	99,300	99,300
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	33,955	
PSI (Mean Area)	50,000	
Lot No.	89	


Tension - Tension Fatigue Test
1/4-28 STUD
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838
"O" Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No.: 22
Date: 2/26/56
Load in Pounds
CYCLES TO FAILURE


Tension - Tension Fatigue Test
1/4-28 STUD
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838
- Logarithmic Mean Life of Five Unplated Parts
- Each Point Indicated for Plated Parts
Low Load = 10% Maximum Load
Testing Speed =1050 CPM
Chart No.: 23
Date: 9/27/57
Load in Pounds
STRESS - P.S.I. (Mean thread area)
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000
20,000
40,000
60,000
3,620
3,288

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 2-26-57

Bolt Design	Stud
Size	1/4-28
Material	MIL-S-6049
Heat Treatment	160,000-180,000 psi
Thread Form	MIL-B-7838
Plate	None
Stress Area	Unengaged
Nut Type	
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Krouse
Capacity	5,000 pound
Speed	1650 cpm

Maximum Load	5,792#	5,068#		4,344#	
Stress	160,000 psi	140,000 psi		120,000 psi	
		unplated	plated	unplated	plated
	5,600	70,000	12,300	362,000	81,300
	5,600	56,500	16,400	350,800	90,200
	4,800	32,400	17,100	159,000	101,300
	4,700	18,500	17,200	133,500	124,600
	4,000	17,000		94,200	
Average	4,940	39,160	15,750	220,060	99,350
Logarithmic Mean Life	4,912	33,540	15,610	191,100	98,060

Maximum Load	3,620#	3,250#
Stress	100,000 psi	90,000 psi
	11,501,200 NF	9,188,300 NF
	8,150,300 NF	8,183,800 NF
	6,145,300	
	3,650,900	
Average	7,361,900	8,686,000
Logarithmic Mean Life	6,772,000	

MECHANICAL PROPERTIES

Date March 14, 1957 For Chart No. 22 and 23

Bolt Description

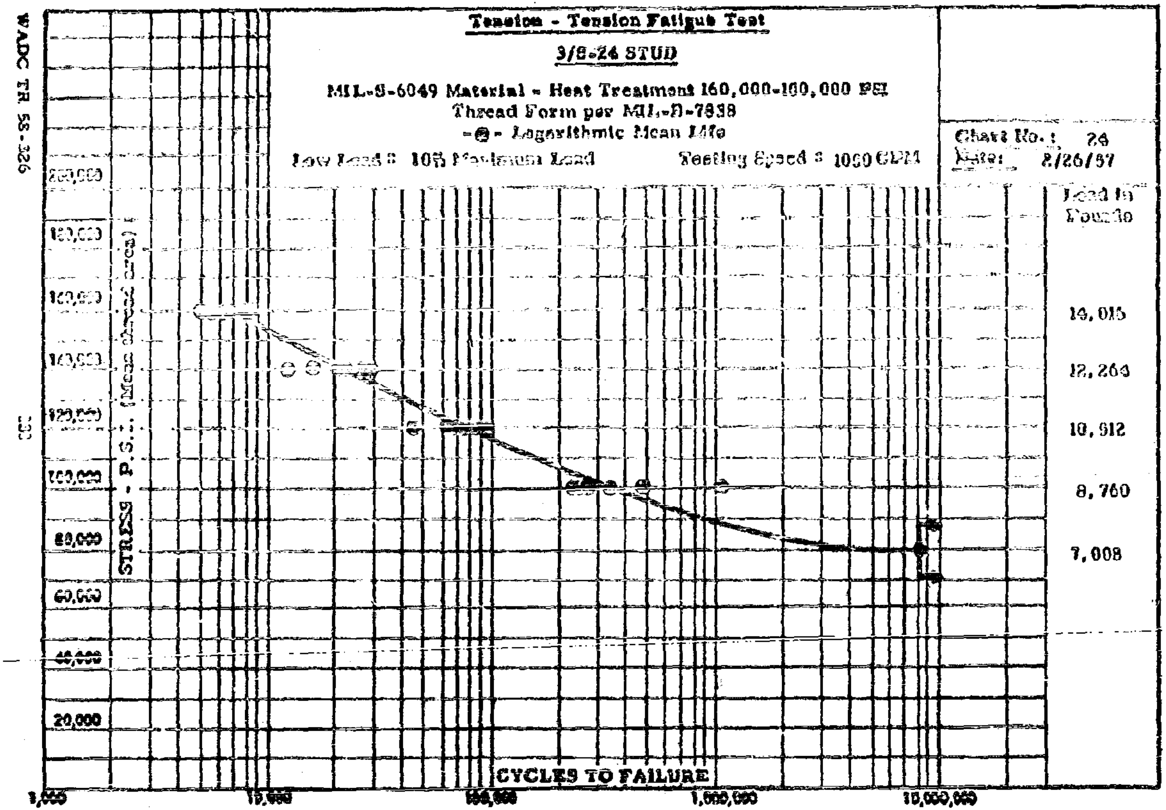
Type	Stud
Size	1/4-28
Material	MIL-S-6049

	Specimen 1	Specimen 2
Bolt Strength Pounds		
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.113 Gage Specimen		
Tensile Strength	101,000	184,000
Yield Strength	172,500	171,500
Elongation - % in 4 Diameter		
.113 Gage Specimen	20.0	11.0
Reduction of Area - %		
.113 Gage Specimen	51.0	51.0
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		

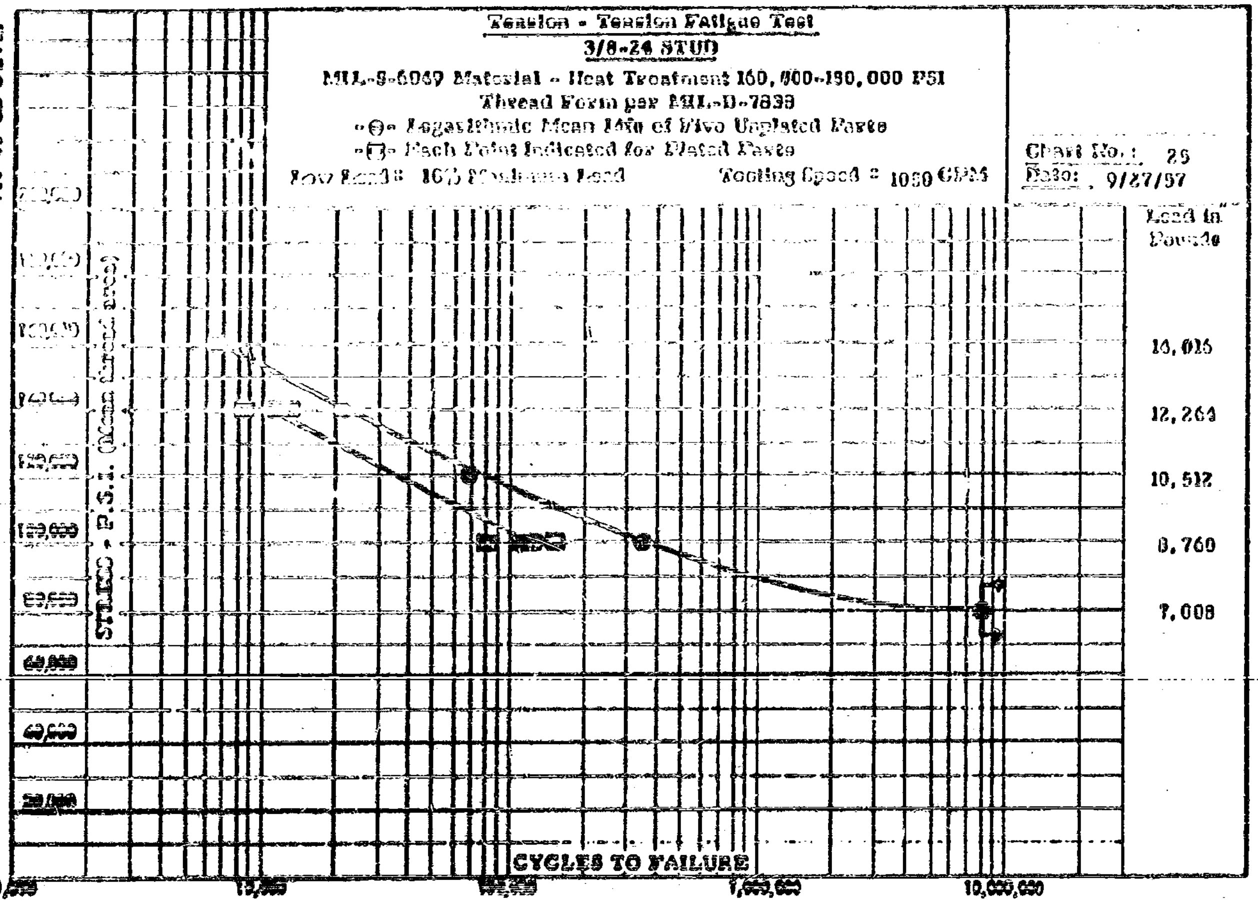
Fatigue Strength @ 8,000,000 Cycles 10% Low Load

Pounds	3,475
PSI (Mean Area)	98,000

Lot No. 74



Tension - Tension Fatigue Test
3/8-24 STUD
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838
-⊖- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1000 CPM
Chart No.: 24
Date: 8/26/57
Load in Pounds
14,015
12,264
10,512
8,760
7,008
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000


Tension - Tension Fatigue Test
3/8-24 STUD
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838
"⊖" Logarithmic Mean Life of Five Unplated Parts
"□" Each Point Indicated for Plated Parts
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No.: 29
Date: 9/27/57
Load in Pounds
14,016
12,264
10,512
8,760
7,008
STRESS - P.S.I. (Mean thread area)
60,000
40,000
20,000
CYCLES TO FAILURE
1,000,000
10,000,000

TENSION- TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 2-26-57

Bolt Design	**Stud**
Size	3/8-24
Material	MIL-S-6049
Heat Treatment	160,000-180,000 psi
Thread Form	MIL-B-7838
Plate	None
Stress Area	.0876 Square inches
Nut Type	Unengaged
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1050 cpm

Maximum Load	14,016#	12,264#		10,512#
Stress	160,000 psi	140,000 psi		120,000 psi
		Unplated	Plated	
	8,100	29,500	8,600	91,200
	7,700	26,300	11,300	86,400
	6,400	22,600	11,400	77,500
	5,700	16,000	13,200	67,200
	5,300	13,300		63,400
				46,800
Average	6,640	21,540	11,130	72,080
Logarithmic Mean Life	6,550	20,600	11,000	70,400

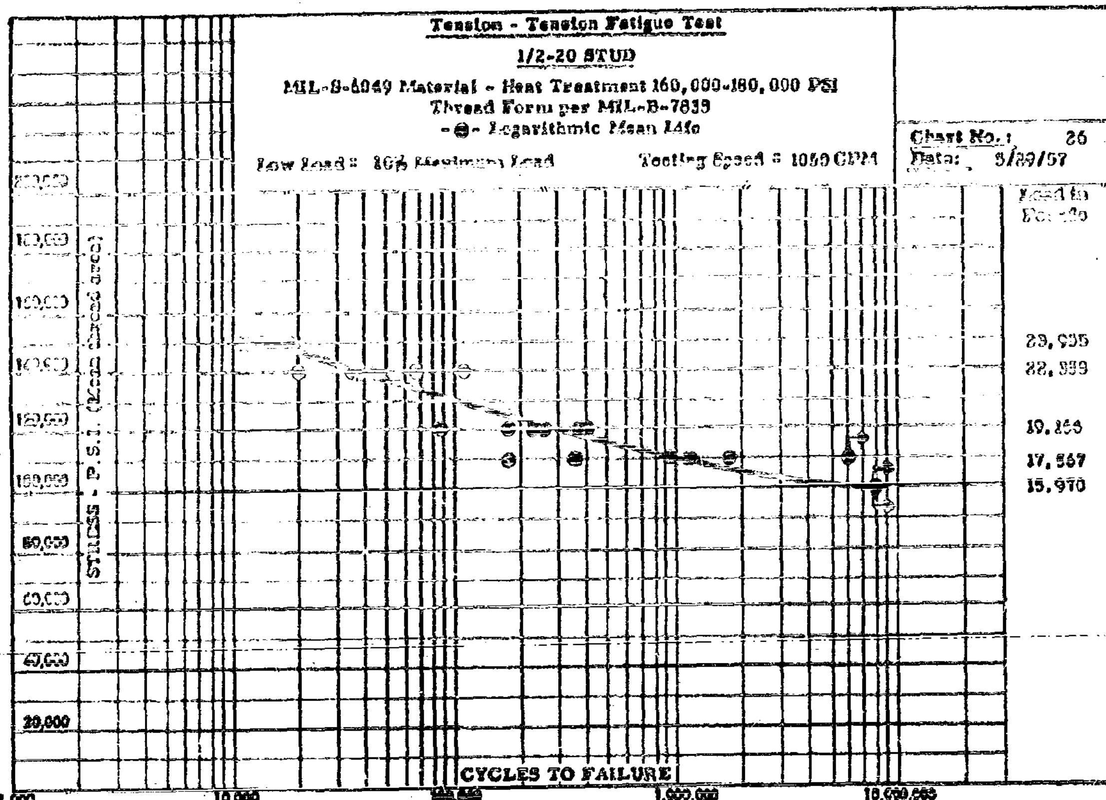
Maximum Load	8,760#		7,008#
Stress	100,000 psi		80,000 psi
	Unplated	Plated	
	1,056,300	80,700	8,000,000
	478,400	113,000	8,000,000
	258,300	124,800	
	242,400	162,300	
	219,700		
Average	450,960	120,200	8,000,000
Logarithmic Mean Life	370,200	116,600	

MECHANICAL PROPERTIES

Date February 26, 1957 For Chart No. 24 and 25

Bolt Description

Type	Stud	
Size	3/8-24	
Material	MIL-S-6049	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.252 Gage Specimen		
Tensile Strength	174,000	173,000
Yield Strength	165,000	161,300
Elongation - % in 4 Diameter		
.252 Gage Specimen	15.0	16.0
Reduction of Area - %		
.252 Gage Specimen	54.5	54.5
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength - Bolt Body Cycles 10% Low Load		
Pounds	7,008	
PSI (Mean Area)	80,000	
Lot No.	52	


Tension - Tension Fatigue Test
1/2-20 STUD
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838
Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No.: 26
Date: 5/29/57
29,935
22,359
19,164
17,567
15,970
80,000
20,000
STRESS - P.S.I.
CYCLES TO FAILURE
1,000
10,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 5-29-57

Bolt Design	Stud
Size	1/2-20
Material	MIL-S-6049
Heat Treatment	160,000-180,000 psi
Thread Form	MIL-B-7838
Plate	None
Stress Area	.1597 Square Inches
Nut Type	Unengaged
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Krouse
Capacity	60,000 pound
Speed	050 cpm

Maximum Load	23,955#	22,350#	19,164#
Stress	150,000 psi	140,000 psi	120,000 psi
	10,900	20,700	86,800
	11,000	34,200	161,900
	15,200	37,200	229,000
	15,700	66,900	358,000
	18,300	108,400	372,600
Average	14,220	53,480	241,660
Logarithmic Mean Life	13,925	45,310	212,100

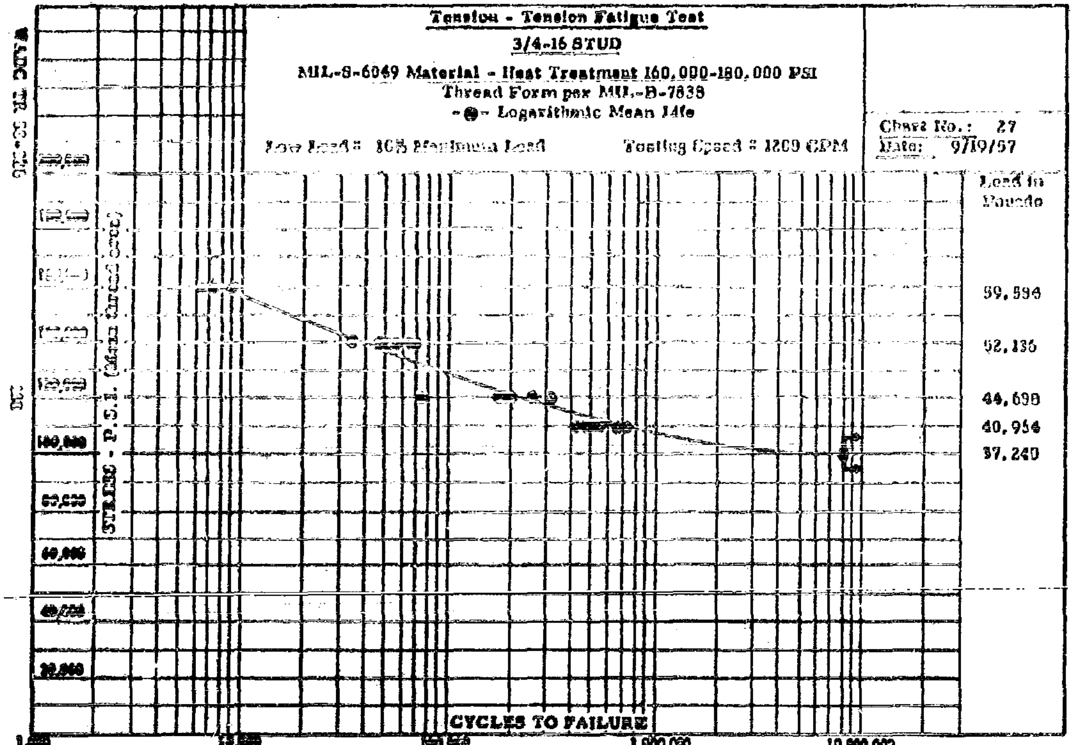
Maximum Load	17,567#	15,970#
Stress	110,000 psi	100,000 psi
	368,200	8,200,000 NF
	1,836,100	8,200,000 NF
	6,500,000 NF	
	166,900	
	1,107,200	
Average	1,995,700	8,200,000
Logarithmic Mean Life	959,200	8,200,000

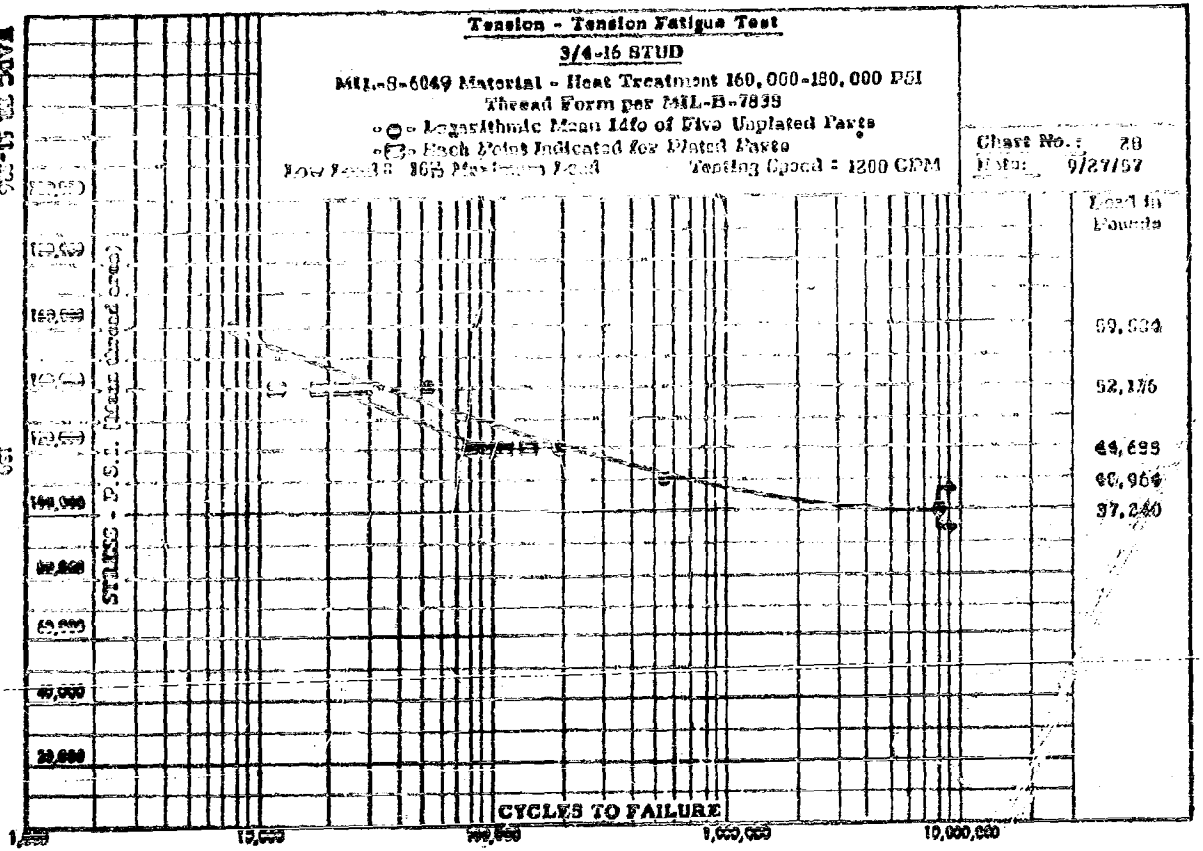
MECHANICAL PROPERTIES

Date May 2, 1957 For Chart No. 26

Bolt Description

Type	Stud	
Size	1/2-20	
Material	MIL-S-6049	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.357 Gage Specimen		
Tensile Strength	182,000	172,500
Yield Strength	164,000	165,000
Elongation - % in 4 Diameter		
.357 Gage Specimen	16.4	12.1
Reduction of Area - %		
.357 Gage Specimen	51.0	50.2
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	15,970	
PSI (Mean Area)	100,000	
Lot No.	00	


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838
-●- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No.: 27
Date: 9/19/57
Load in Pounds
59,594
52,136
44,698
40,954
37,240
STRESS - P.S.I. (Mean thread area)
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-6049 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7839
= Logarithmic Mean Life of Five Unplated Parts
= Each Point Indicated for Plated Parts
Testing Speed = 1200 CPM
Chart No.: 28
Date: 9/27/57
Load in Pounds
59,634
52,176
44,699
40,964
37,260
140,000
80,000
60,000
40,000
20,000
STRESS - P.S.I.
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 9-19-57

Bolt Design	**Stud**
Size	**3/4-16**
Material	**MIL-S-6049**
Heat Treatment	**160,000-180,000 psi**
Thread Form	**MIL-B-7838**
Plate	**None**
Stress Area	**0.3724 Square inches**
Nut Type	**Unengaged**
Style	
Material	
Heat Treatment	
Testing Machine	
Make	**Ivy**
Capacity	**60,000 pound**
Speed	**1200 cpm**

Maximum Load	**59,584#**	**52,136#**	
Stress	**160,000 psi**	**140,000 psi**	
		Unplated	**Plated**
	6,500	35,500	13,600
	7,100	45,000	18,700
	7,100	54,100	24,100
	7,300	64,600	28,200
	9,300	68,700	
Average	7,440	53,740	21,150
Logarithmic Mean Life	7,302	52,280	20,390

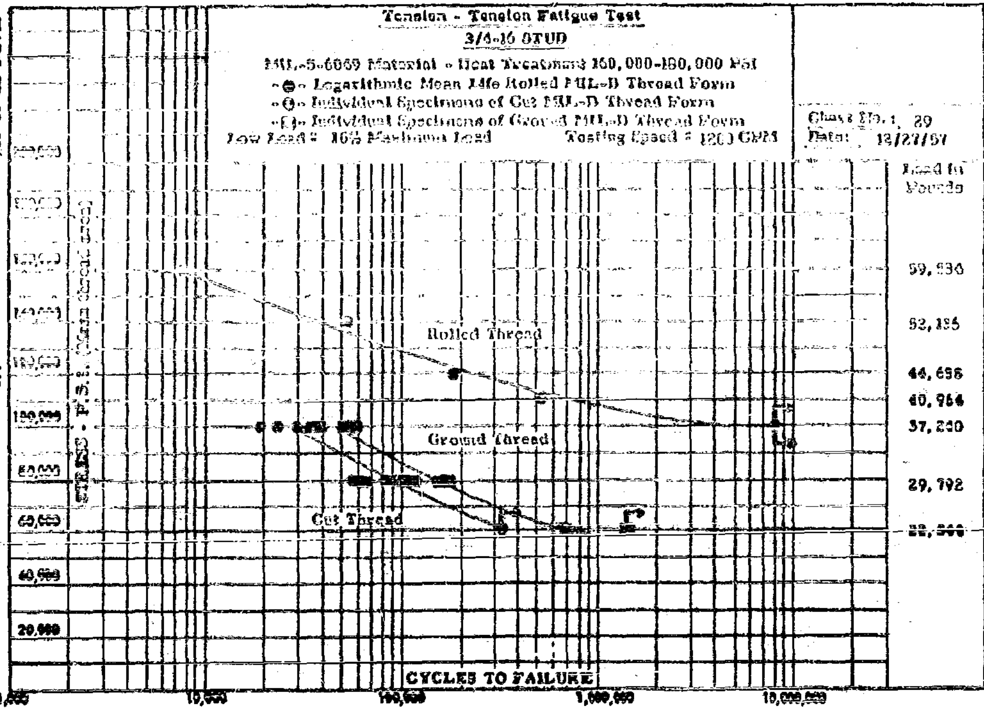
Maximum Load	**44,688#**		**40,964#**	**37,240#**
Stress	**120,000 psi**		**110,000 psi**	**100,000 psi**
	Unplated	**Plated**		
	75,000	82,300	426,000	8,000,000 NF
	194,000	96,800	498,000	8,000,000 NF
	207,000	112,300	525,000	
	262,000	151,100	658,000	
	326,000		700,000	
Average	212,800	110,600	561,400	8,000,000
Logarithmic Mean Life	191,500	107,800	552,100	8,000,000

MECHANICAL PROPERTIES

Date May 17, 1957 **For Chart No.** 27 and 28

Bolt Description

Type	Stud	
Size	3/4-16	
Material	MIL-S-6049	
Bolt Strength Pounds	**Specimen 1**	**Specimen 2**
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	165,000	163,500
Yield Strength	155,100	150,200
Elongation - % in 4 Diameters		
.505 Gage Specimen	16.0	16.0
Reduction of Area - %		
.505 Gage Specimen	51.0	50.4
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	37,240	
PSI (Mean Area)	100,000	
Lot No.	77	


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-6069 Material - Heat Treatment 160,000-180,000 Psi
-●- Logarithmic Mean Life Rolled MIL-B Thread Form
-⊖- Individual Specimens of Cut MIL-B Thread Form
-[]- Individual Specimens of Ground MIL-B Thread Form
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No. 29
Date: 12/27/57
Load in Pounds
59,836
52,185
44,656
40,964
37,220
29,792
22,344
Rolled Thread
Ground Thread
Cut Thread
STRESS - P.S.I.
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 12/27/57

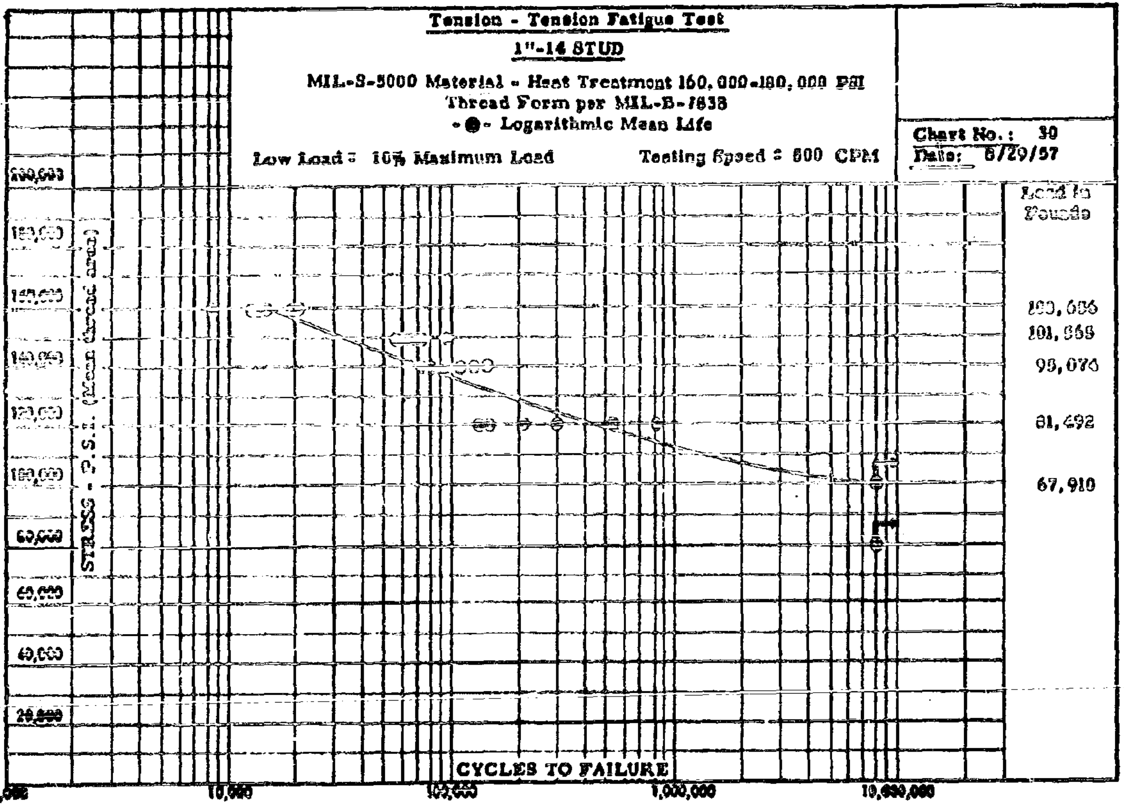
Bolt Design	Stud	Stud
Size	3/4-16	3/4-16
Material	AMS 6322	AMS 6322
Heat Treatment	160,000-180,000 psi	160,000-180,000 psi
Thread Form	Cut UNF 3A	Ground MIL-B-7838
Plate	None	None
Stress Area	.3724 Square Inches	
Nut Type	Unengaged	Unengaged
Style		
Material		
Heat Treatment		
Testing Machine		
Make	Ivy	Ivy
Capacity	60,000 pound	60,000 pound
Speed	1200 cpm	1200 cpm
	Cut Thread	Ground Thread
Load	37,240#	37,240#
Stress	100,000 psi	100,000 psi
	25,000	33,000
	19,000	34,000
	29,000	52,000
	41,000	58,000
Load	29,792#	29,792#
Stress	80,000 psi	80,000 psi
	58,000	63,000
	82,000	98,000
	97,000	165,000
	124,000	178,000
Load	22,344#	22,344#
Stress	60,000 psi	60,000 psi
	331,000	1,300,000 NF
		706,000

MECHANICAL PROPERTIES

Date December 28, 1957 **For Chart No.** 29

Bolt Description	**Cut Thread**		**Ground Thread**	
Type	Stud		Stud	
Size	3/4-16		3/4-16	
Material	MIL-S-6049		MIL-S-6049	
Bolt Strength Pounds	Specimen 1	Specimen 2	Specimen 1	Specimen 2
Ultimate Tensile				
Yield Strength				
Material Strength PSI				
.505 Gage Specimen				
Tensile Strength	175,000	172,000	166,000	160,500
Yield Strength	165,000	161,600	152,500	155,000
Elongation - % in 4 Diameter				
.505 Gage Specimen	13.5	11.5	13.5	14.0
Reduction of Area - %				
.505 Gage Specimen	55.7	54.1	50.9	61.1
Shear Strength - Bolt Body				
Pounds - Double Shear				
PSI				
Fatigue Strength @ 8,000,000 Cycles 10% Low Load				
Pounds				
PSI (Mean Area)				

Lot No. 526 560


Tension - Tension Fatigue Test
1"-14 STUD
MIL-S-5000 Material - Heat Treatment 160,000-180,000 PSI
Thread Form per MIL-B-7838
-●- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 800 CPM
Chart No.: 30
Date: 6/29/57
Load in Pounds
95,076
81,492
67,910
STRESS - P.S.I. (Mean thread area)
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 8-29-57

Bolt Design	Stud
Size	1"-14
Material	MIL-S-5000
Heat Treatment	160,000-180,000 psi
Thread Form	
Plate	
Stress Area	.6791 Square inches
Nut Type	Unengaged
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Amsler
Capacity	220,000 pound
Speed	500 cpm

Maximum Load	108,656#	101,865#	95,074#
Stress	160,000 psi	150,000 psi	140,000 psi
	8,600	60,000	124,000
	13,100	60,000	73,100
	14,200	66,000	76,800
	19,200	69,000	135,000
	22,300	96,000	151,000
Average	15,480	70,200	111,980
Logarithmic Mean Life	13,900	69,090	93,600

Maximum Load	81,492#	67,910#
Stress	120,000 psi	100,000 psi
	166,000	8,000,000 NF
	174,000	8,000,000 NF
	207,000	
	816,000	
	540,000	
Average	380,600	8,000,000
Logarithmic Mean Life	306,300	8,000,000

MECHANICAL PROPERTIES

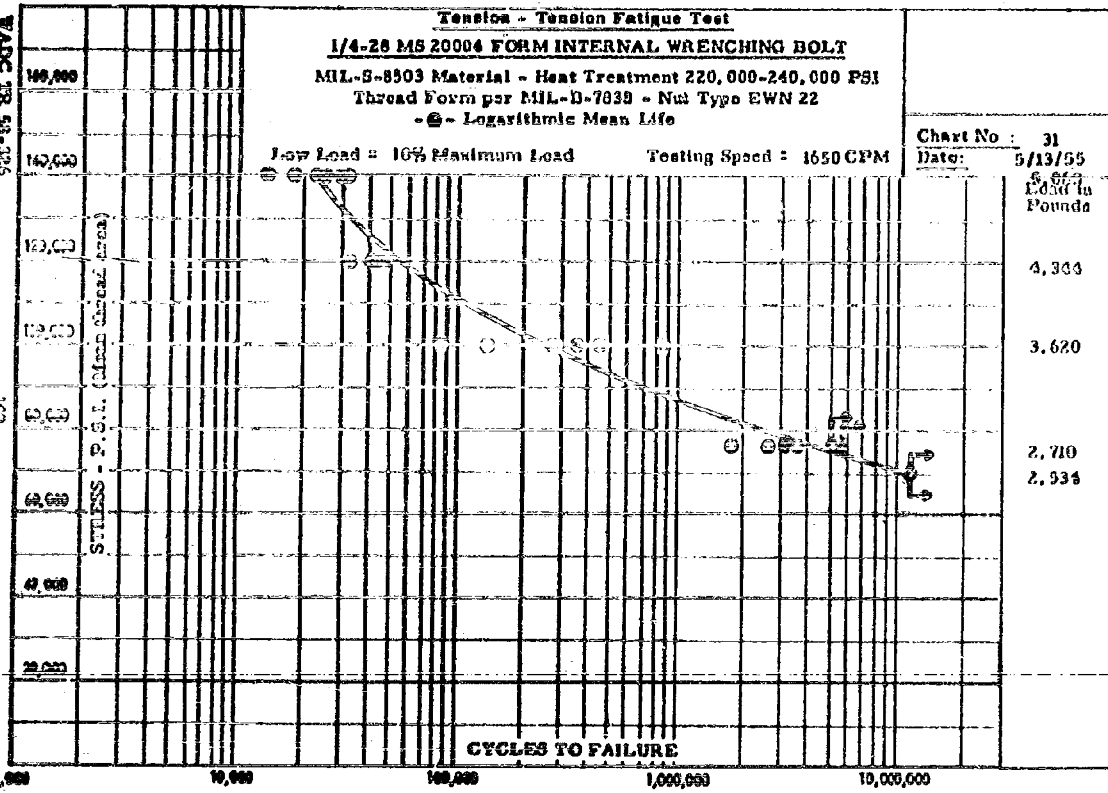
Date August 29, 1957 For Chart No. 30

Bolt Description

Type	Stud	
Size	1"-14	
Material	MIL-S-5000	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	179,000	180,000
Yield Strength	172,500	172,500
Elongation - % in 4 Diameter		
.505 Gage Specimen	13.5	12.5
Reduction of Area - %		
.505 Gage Specimen	52.0	46.3
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	67,910	
PSI (Mean Area)	100,000	
Lot No.	199	

APPENDIX II

RAW DATA FOR 220,000 PSI PARTS


Tension - Tension Fatigue Test
1/4-28 MS 20004 FORM INTERNAL WRENCHING BOLT
MIL-S-8503 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838 - Nut Type EWN 22
-⊖- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed : 1650 CPM
Chart No : 31
Date: 5/13/55
Load in Pounds
4,344
3,620
2,710
2,534
STRESS - P.S.I. (Mean thread area)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 5-13-58

Bolt Design	MS 20004
Size	1/4-28
Material	MIL-S-8503
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium Plate per QQ-P-416 Type I, Class C
Stress Area	.0362 Square inches
Nut Type	
Style	EWN 22
Material	AISI 8630
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	5,000 pound
Speed	1650 cpm

Maximum Load	5,060#	4,344#	3,620#
Stress	140,000 psi	120,000 psi	100,000 psi
	31,100	52,100	842,900
	29,000	50,600	433,900
	22,300	49,300	354,500
	18,500	31,400	135,900
	14,300		83,800
Average	23,040	45,850	370,000
Logarithmic Mean Life	22,140	44,830	271,600

Maximum Load	2,710#	2,534#
~~Stress~~	~~77,000 (MIL-B)~~	~~70,000 psi~~
	5,612,100 NF	10,283,300 NF
	5,421,000 NF	10,283,300 NF
	3,463,200	
	2,451,700	
	1,862,500	
Average	3,762,100	10,283,300
Logarithmic Mean Life	3,409,000	10,283,300

MECHANICAL PROPERTIES

Date May 13, 1955 For Chart No. 31

Bolt Description

Type	MS 20004	
Size	1/4-28	
Material	MIL-S-8503	

Bolt Strength Pounds

	Specimen 1	Specimen 2
Ultimate Tensile	9,300	9,350
Yield Strength	7,900	8,000

Material Strength PSI

.113 Gage Specimen		
Tensile Strength	234,000	236,000
Yield Strength	190,000	190,000

Elongation - % in 4 Diameter

.113 Gage Specimen	16.5	16.5

Reduction of Area - %

.113 Gage Specimen	60.4	47.2

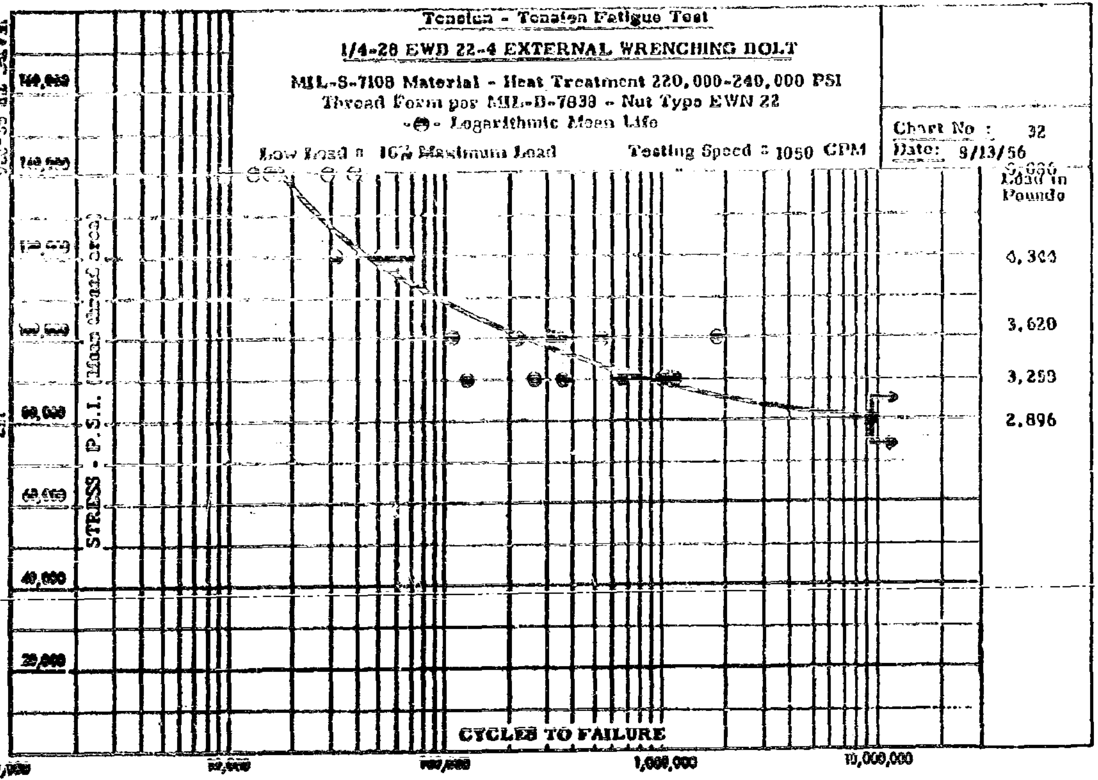
Shear Strength - Bolt Body

Pounds - Double shear	13,200	14,270
PSI	134,400	145,000

Fatigue Strength @ 8,000,000 Cycles 10% Low Load

Pounds	2,534
PSI (Mean Area)	70,000

Lot No. 279S4148A



Tension - Tension Fatigue Test
1/4-28 EWB 22-4 EXTERNAL WRENCHING BOLT
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838 - Nut Type EWN 22
- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No : 32
Date: 9/13/56
Load in Pounds
4,304
3,620
3,258
2,896
STRESS - P.S.I. (Mean thread area)
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 8-13-56

Bolt Design	EWB 22-4
Size	1/4-28
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium Fluoborate per NAS 672
Stress Area	.0362 Square Inches
Nut Type	
Style	EWN 22
Material	AMS 6280
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1050 cpm

Maximum Load	5,068#	4,344#	3,620#
Stress	140,000 psi	120,000 psi	100,000 psi
	39,600	59,600	1,837,100
	29,200	56,400	551,300
	16,400	49,700	355,300
	13,100	41,300	217,500
	9,100	22,300	106,500
Average	21,480	95,860	613,540
Logarithmic Mean Life	18,660	43,400	383,900

Maximum Load	3,258#	2,896#
Stress	90,000 psi	80,000 psi
	1,222,600	9,744,800 NF
	1,160,900	9,744,800 NF
	1,085,000	
	387,700	
	225,000	
Average	816,200	9,744,800
Logarithmic Mean Life	669,400	9,744,800

MECHANICAL PROPERTIES

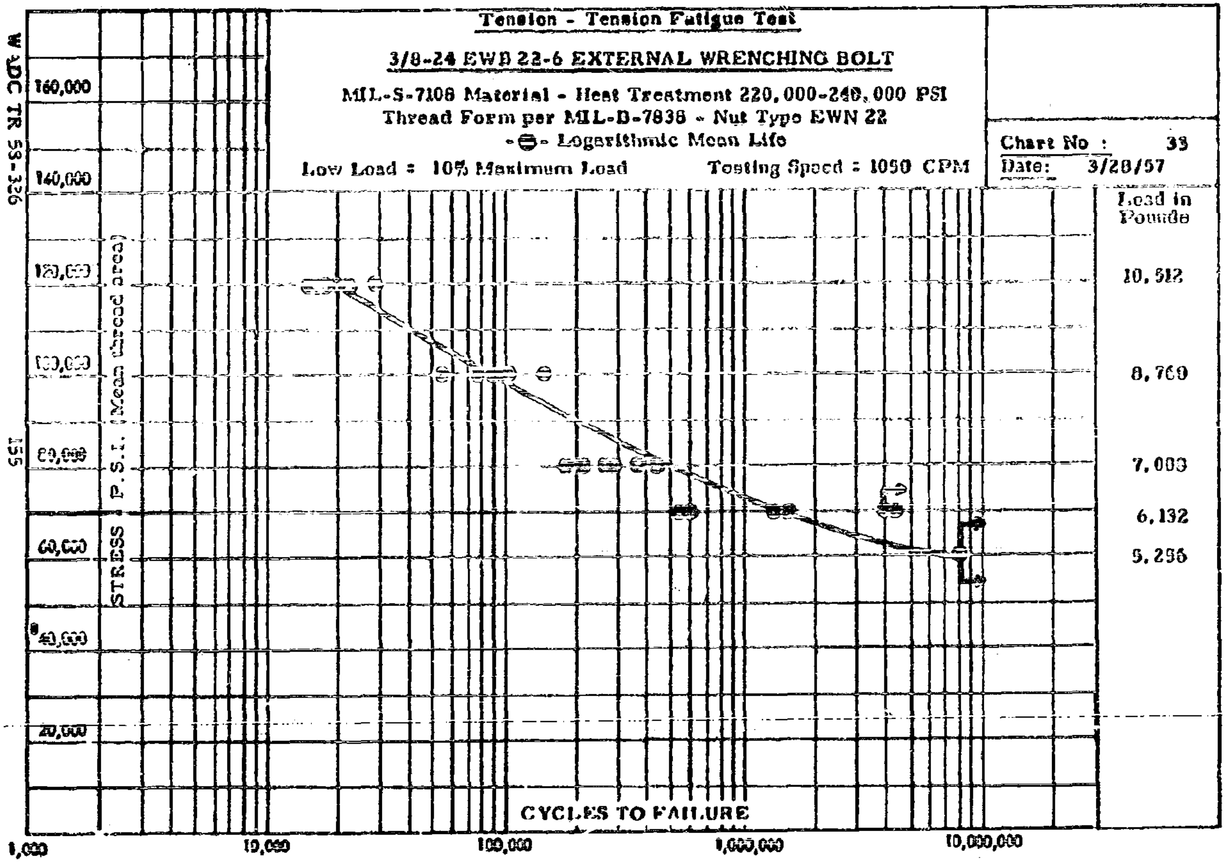
Date August 13, 1956 For Chart No. 32

	Specimen 1	Specimen 2
Bolt Description		
Type	EWB 22-4	
Size	1/4-28	
Material	MIL-S-7108	
Bolt Strength Pounds		
Ultimate Tensile	9,620	9,940
Yield Strength	8,000	8,300
Material Strength PSI		
.113 Gage Specimen		
Tensile Strength	237,500	249,000
Yield Strength	227,500	247,500
Elongation - % in 4 Diameter		
.113 Gage Specimen	12.5	12.5
Reduction of Area - %		
.113 Gage Specimen	32.0	34.0
Shear Strength - Bolt Body		
Pounds - Double Shear	13,820	13,680
PSI	140,700	139,300
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	2,896	
PSI (Mean Area)	80,000	
Lot No.	628S9172	

MECHANICAL PROPERTIES

Date August 13, 1956 For Chart No. 32

	Specimen 1	Specimen 2
Bolt Description		
Type	EWB 22-4	
Size	1/4-28	
Material	MIL-S-7108	
Bolt Strength Pounds		
Ultimate Tensile	9,620	9,940
Yield Strength	8,000	8,300
Material Strength PSI		
.113 Gage Specimen		
Tensile Strength	237,500	249,000
Yield Strength	227,500	247,500
Elongation - % in 4 Diameter		
.113 Gage Specimen	12.5	12.5
Reduction of Area - %		
.113 Gage Specimen	32.0	34.0
Shear Strength - Bolt Body		
Pounds - Double Shear	13,820	13,680
PSI	140,700	139,300
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	2,896	
PSI (Mean Area)	80,000	
Lot No.	62859172	


Tension - Tension Fatigue Test
3/8-24 EWB 22-6 EXTERNAL WRENCHING BOLT
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838 - Nut Type EWN 22
- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No : 33
Date: 3/28/57
Load in Pounds
10,512
8,760
7,008
6,132
5,256
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
STRESS P.S.I. (Mean thread area)
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 3-28-57

Bolt Design	EWB 22-6
Size	3/8-24
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium Fluoborate per NAS 672
Stress Area	.0876 Square inches
Nut Type	
Style	EWN 22
Material	AMS 6280
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1050 cpm

Maximum Load	10,512#	8,760#	7,008#
Stress	120,000 psi	100,000 psi	80,000 psi
	28,800	168,500	438,400
	21,400	107,300	376,000
	19,700	98,400	269,800
	18,500	77,000	214,400
	15,800	54,100	173,000
Average	20,840	101,060	294,320
Logarithmic Mean Life	20,520	94,180	277.500

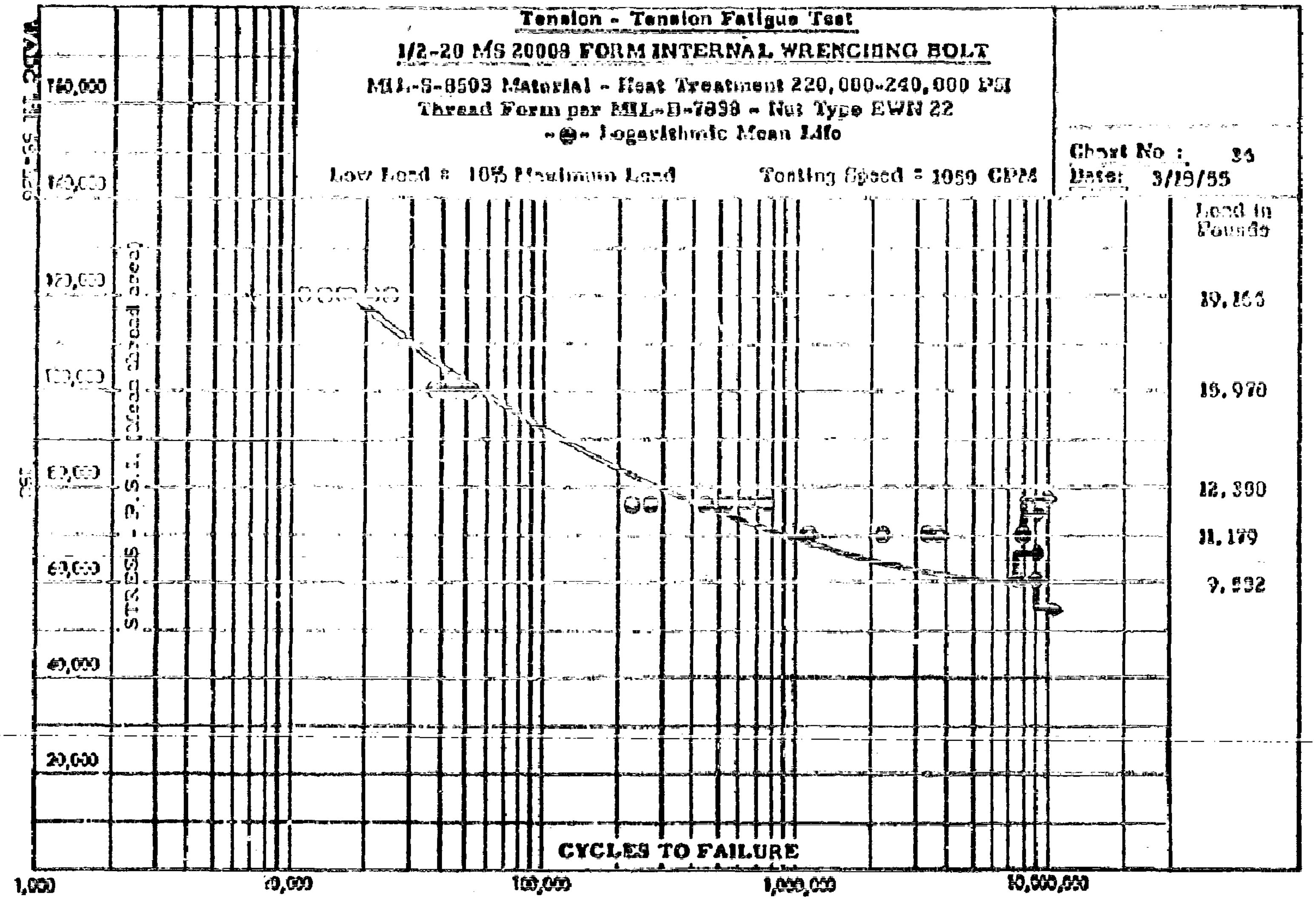
Maximum Load	6,132#	5,256#
Stress	70,000 psi	60,000 psi
	4,218,000	8,379,000 NF
	4,000,000 NF	8,379,000 NF
	1,569,000 NF	
	547,600	
	547,200	
Average	2,174,660	8,379,000
Logarithmic Mean Life	1,511,000	8,379.000

MECHANICAL PROPERTIES

Date March 28, 1957 For Chart No. 33

Bolt Description

Type	EWB 22-6	
Size	3/8-24 x 4 11/16	
Material	MIL-S-7108	
Bolt Strength Pounds	**Specimen 1**	**Specimen 2**
Ultimate Tensile	23,300	22,800
Yield Strength	21,275	18,000
Material Strength PSI		
.252 Gage Specimen		
Tensile Strength	242,300	242,900
Yield Strength	206,100	204,100
Elongation - % in 4 Diameter		
.252 Gage Specimen	10.50	19.0
Reduction of Area - %		
.252 Gage Specimen	46.0	47.6
Shear Strength - Bolt Body		
Pounds - Double Shear	30,750	30,900
PSI	139,300	139,900
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	5,256	
PSI (Mean Area)	60,000	
Lot No.	629S9K75	


Tension - Tension Fatigue Test
1/2-20 MS 20008 FORM INTERNAL WRENCHING BOLT
MIL-S-8503 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838 - Nut Type EWN 22
-⊕- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No.: 34
Date: 3/19/55
Load in Pounds
19,166
15,970
12,390
11,179
9,582
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
STRESS - P.S.I. (Mean thread area)
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 3-18-57

Bolt Design	MS 20008
Size	1/2-20
Material	MIL-S-8503
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium Plate per QQ-P-416 Type I, Class C
Stress Area	0.1597 Square Inches
Nut Type	
Style	EWN 22
Material	AISI 8630
Heat Treatment	RC 27-32
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1050 cpm

Maximum Load	19,164#	15,970#	12,300#
Stress	120,000 psi	100,000 psi	MIL-D
	24,000	54,800	747,000
	21,700	49,500	613,000
	18,300	45,400	564,500
	16,500	43,200	295,800
	13,000	37,900	250,000
Average	18,700	46,160	499,240
Logarithmic Mean Life	18,290	45,810	451,300

Maximum Load	11,179#	9,582#
Stress	70,000 psi	60,000 psi
	8,000,000 NF	8,020,500 NF
	8,000,000 NF	8,020,500 NF
	3,780,000	
	2,393,000	
	1,114,400	
Average	4,663,500	8,020,500
Logarithmic Mean Life	3,564,000	8,020,500

[illegible]

Date [illegible] Lot No. [illegible]

Bolt Description

Type [illegible]
Size [illegible]
Material [illegible]

Bolt Strength Pounds

	[illegible]	[illegible]
Ultimate [illegible]	[illegible]	[illegible]
Yield Strength	[illegible]	[illegible]

Material Strength PSI

[illegible]

[illegible]	[illegible]	[illegible]
Yield Strength	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]

[illegible]

[illegible]		[illegible]

[illegible]

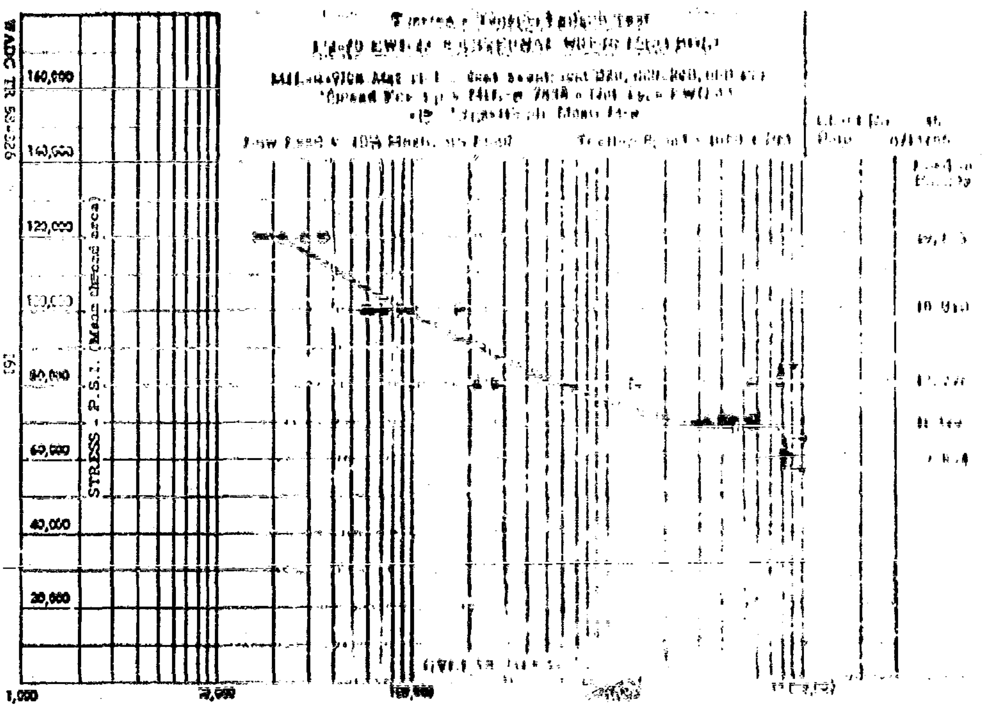
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]

Lab No. [illegible]

[illegible]


STRESS - P.S.I. (Mean thread area)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
1,000
10,000
100,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 8-13-56

Bolt Design	**EWB 22-8**
Size	**1/2-20**
Material	**MIL-S-7108**
Heat Treatment	**220,000-240,000 psi**
Thread Form	**MIL-B-7838**
Plate	**Cadmium Fluoborate per NAS 672**
Stress Area	**.1597 Square inches**
Nut Type	
Style	EWN 22
Material	AMS 6280
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1650 cpm

Maximum Load	19,164#	15,970#	12,776#
Stress	120,000 psi	100,000 psi	80,000 psi
	34,600	184,200	8,794,800
	28,800	100,700	5,405,900
	19,100	72,500	2,885,900
	18,100	63,000	282,000
	18,000	60,000	221,000
Average	23,720	96,080	3,517,700
Logarithmic Mean Life	22,160	87,340	1,536,000

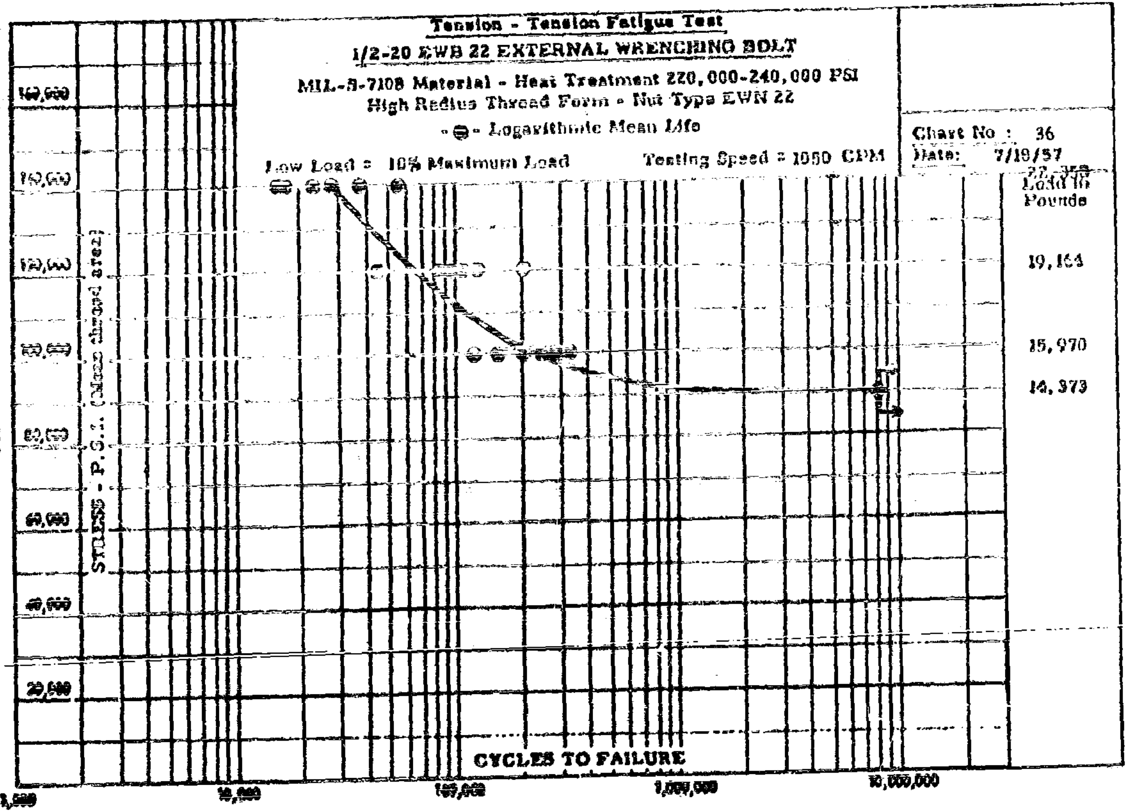
Maximum Load	11,179#	9,582#
Stress	70,000 psi	60,000 psi
	5,820,600	8,290,200
	5,346,800	8,290,200
	4,038,100	
	3,223,300	
Average	4,607,200	8,290,200
Logarithmic Mean Life	4,455,000	

MECHANICAL PROPERTIES

Date August 13, 1956 For Chart No. 35

Bolt Description

Type	EWB 22-8 - MIL-B Thread	
Size	1/2-20	
Material	MIL-S-7108	
Bolt Strength Pounds		
	Specimen 1	Specimen 2
Ultimate Tensile	41,700	41,700
Yield Strength	30,500	31,500
Material Strength PSI		
.357 Gage Specimen		
Tensile Strength	239,000	239,000
Yield Strength	202,000	196,000
Elongation - % in 4 Diameter		
.357 Gage Specimen	11.6	11.6
Reduction of Area - %		
.357 Gage Specimen	50.2	48.6
Shear Strength - Bolt Body		
Pounds - Double Shear	56,900	56,200
PSI	289,700	286,200
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	10,700	
PSI (Mean Area)	67,000	
Lot No.	630S9M94	



Tension - Tension Fatigue Test
1/2-20 EWB 22 EXTERNAL WRENCHING BOLT
MIL-B-7108 Material - Heat Treatment 220,000-240,000 PSI
High Radius Thread Form - Nut Type EWN 22
- ⊖ - Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No : 36
Date: 7/19/57
Load in Pounds
19,164
15,970
14,373
STRESS - P.S.I.
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
1,000
10,000
100,000
1,000,000
10,000,000
CYCLES TO FAILURE

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress ARea

Date: 7-18-57

Bolt Design	EWB 22-8		
Size	1/2-20		
Material	MIL-S-7108		
Heat Treatment	220,000-240,000 psi		
Thread Form	High Radius		
Plate	Cadmium Fluoborate per NAS 672		
Stress Area	0.1597		
Nut Type			
Style	EWN 22		
Material	AMS 6280		
Heat Treatment	Rc 27-32		
Testing Machine			
Make	Krouse		
Capacity	60,000 pound		
Speed	850 cpm		

Maximum Load	22,358#	19,164#	15,970#
Stress	140,000 psi	120,000 psi	100,000 psi
	18,000	82,900	305,400
	18,500	93,200	230,500
	23,100	43,800	286,500
	54,100	202,000	125,900
	37,800	121,300	142,600
Average	30,300	108,640	218,180
Logarithmic Mean Life	27,500	108,600	203,000

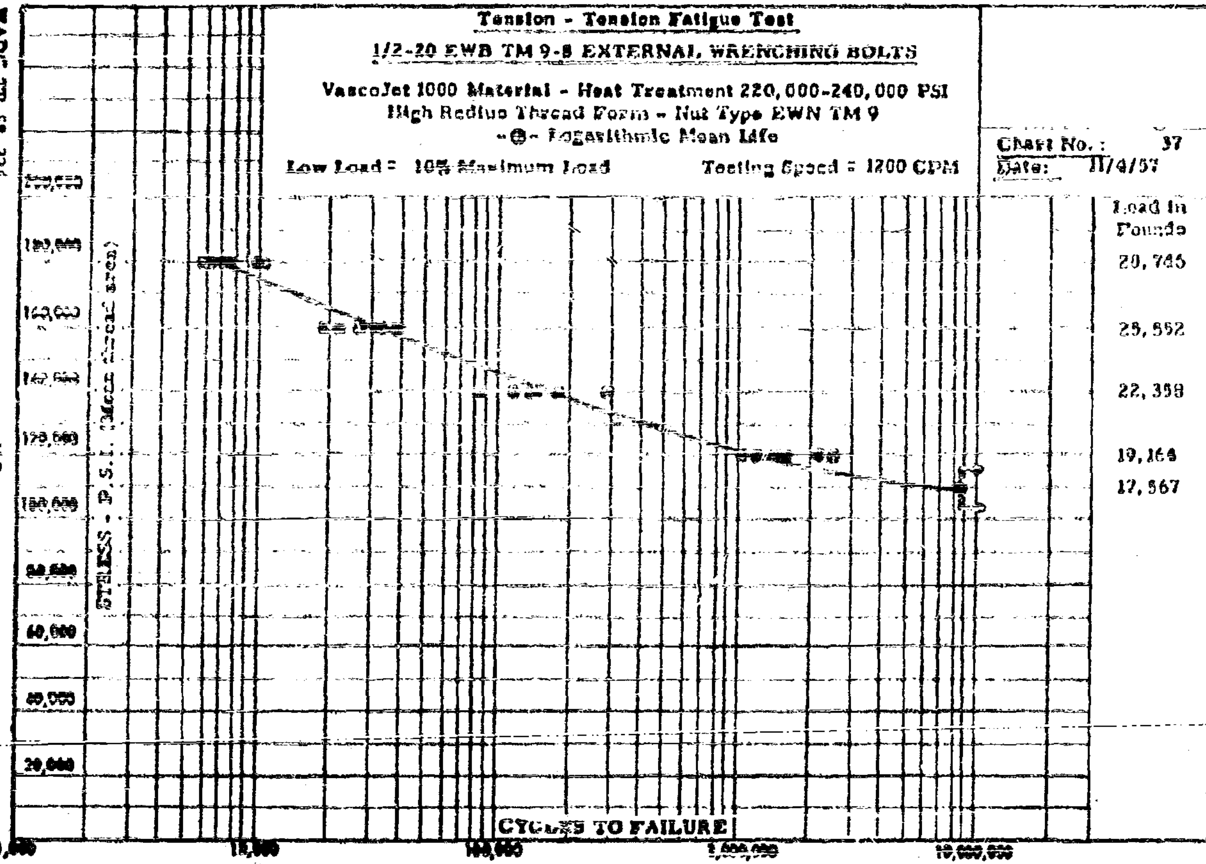
Maximum Load	14,383#
Stress	90,000 psi
	8,000,000
	8,000,000
Average	8,000,000
Logarithmic Mean Life	8,000,000

MECHANICAL PROPERTIES

Date May 16, 1957 For Chart No. 36

Bolt Description

Type	EWB 22-8 High Radius Thread	
Size	1/2-20	
Material	MIL-S-7108	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile	43,000	43,000
Yield Strength	30,600	30,000
Material Strength PSI		
.357 Gage Specimen		
Tensile Strength	237,500	240,500
Yield Strength	198,000	200,000
Elongation - % in 4 Diameter		
.357 Gage Specimen	11.6	11.6
Reduction of Area - %		
.357 Gage Specimen	49.4	49.4
Shear Strength - Bolt Body		
Pounds - Double Shear	56,900	56,200
PSI	289,700	286,200
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	14,373	
PSI (Mean Area)	90,000	
Lot No.	87	


Tension - Tension Fatigue Test
1/2-20 EWB TM 9-8 EXTERNAL WRENCHING BOLTS
VascoJet 1000 Material - Heat Treatment 220,000-240,000 PSI
High Radius Thread Form - Nut Type EWN TM 9
-⊕- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No.: 37
Date: 11/4/57
Load in Pounds
20,745
25,552
22,358
19,164
17,567
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 11-4-57

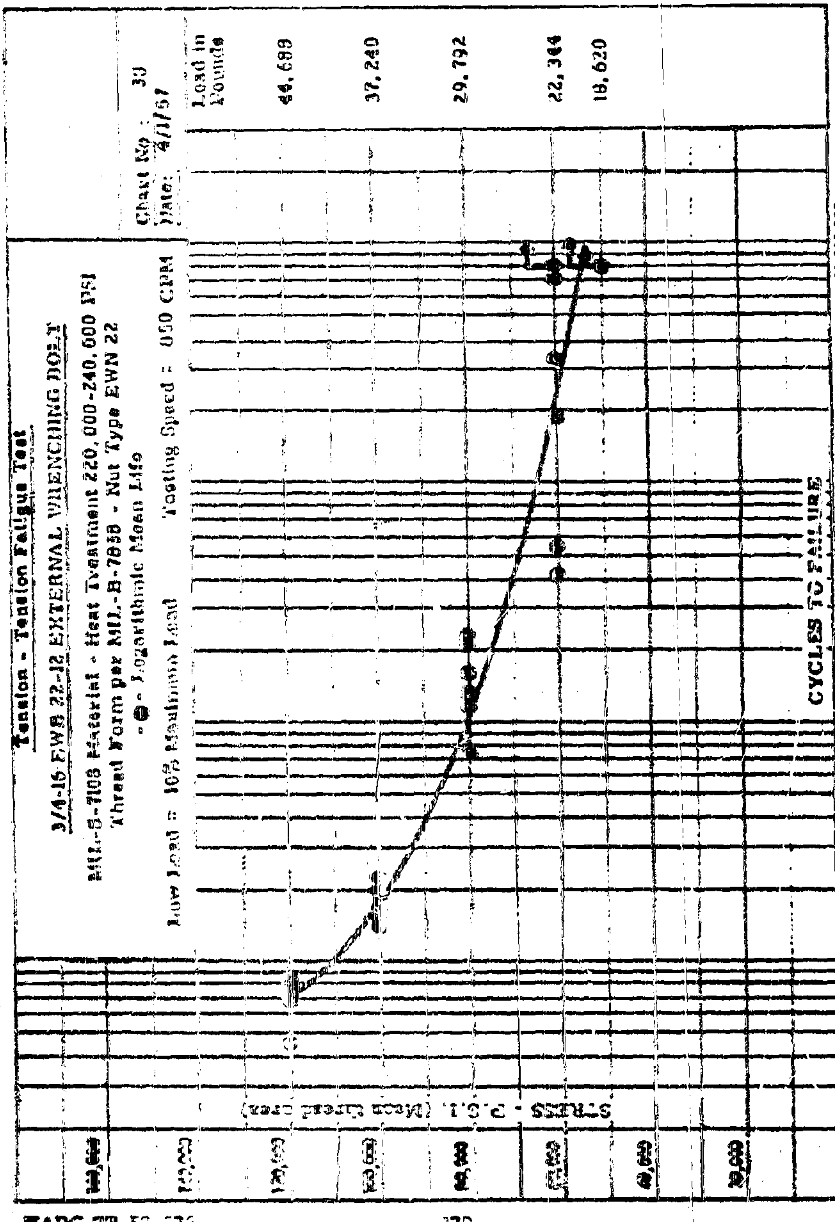
Bolt Design	EWB TM 9-8
Size	1/2-20
Material	VascoJet 1000
Heat Treatment	220,000-240,000 psi
Thread Form	High Radius
Plate	AMS 2416
Stress Area	.1597 Square inches
Nut Type	
Style	EWN TM 9
Material	AMS 6304
Heat Treatment	Rc 27-32
Testing Machine	
Make	Ivy
Capacity	60,000 pound
Speed	1200 cpm

Maximum Load	28,746#	25,552#	22,358#
Stress	180,000 psi	160,000 psi	140,000 psi
	6,000	19,000	85,000
	6,000	23,000	135,000
	7,000	32,000	154,000
	10,000	32,000	177,000
	10,000	36,000	292,000
Average	7,800	28,400	168,600
Logarithmic Mean Life	7,591	27,630	155,600

Maximum Load	19,164#	17,567#
Stress	120,000 psi	110,000 psi
	1,141,000	9,136,000
	1,333,000	8,746,000
	1,545,000	
	2,195,000	
	2,240,000	
Average	1,690,000	8,000,000
Logarithmic Mean Life	1,631,000	8,000,000

MECHANICAL PROPERTIES

Date July 26, 1957	**For Chart No.** 37	
Bolt Description		
Type	EWB TM 9	
Size	1/2-20 x 5	
Material	VascoJet 1000	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile	41,800	40,000
Yield Strength	31,500	30,000
Material Strength PSI		
Gage Specimen		
Tensile Strength	235,000	235,000
Yield Strength	205,000	200,000
Elongation - % in 4 Diameter		
Gage Specimen	12.1	11.4
Reduction of Area - %		
Gage Specimen	31.3	32.3
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	17,567	
PSI (Mean Area)	110,633	
Lot No.	207	


Tension - Tension Fatigue Test
3/4-16 EWB 22-12 EXTERNAL WRENCHING BOLT
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838 - Nut Type EWN 22
- ⊖ - Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 850 CPM
Chart No.: 39
Date: 4/1/57
Load in Pounds
44,688
37,240
29,792
22,344
18,620
STRESS - P.S.I. (Mean thread area)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 4-1-57

Bolt Design	EWB 22-12
Size	3/4-16
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838a
Plate	Cadmium Fluoborate per NAS 672
Stress Area	.3724 Square inches
Nut Type	
Style	EWN 22
Material	AMS 6280
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	60,000 pound
Speed	850 cpm

Maximum Load	44,688#	37,240#	29,792#
Stress	120,000 psi	100,000 psi	80,000 psi
	4,400	15,100	74,600
	6,000	16,100	128,000
	7,100	19,700	163,400
	7,700	20,000	205,200
	8,900	21,300	213,400
Average	6,980	18,440	157,100
Logarithmic Mean Life	6,800	18,280	127,100

Maximum Load	22,344#	18,620#
Stress	60,000 psi	50,000 psi
	401,300	8,143,200 NF
	547,500	8,143,200 NF
	2,321,800	
	7,398,900	
	8,194,300	
Average	3,772,800	8,143,200
Logarithmic Mean Life	1,987,000	8,143,200

MECHANICAL PROPERTIES

Date April 1, 1957 For Chart No. 10

Bolt Description

Type	EWB 22-12 MIL-B Thread	
Size	3/4-16	
Material	MIL-S-7108	

Bolt Strength Pounds

	Specimen 1	Specimen 2
Ultimate Tensile	96,000	95,100
Yield Strength	70,100	70,100

Material Strength PSI

	Specimen 1	Specimen 2
.505 Gage Specimen		
Tensile Strength	240,000	231,000
Yield Strength	107,500	191,250

Elongation - % in 4 Diameter

	Specimen 1	Specimen 2
.505 Gage Specimen	12.5	12.5

Reduction of Area - %

	Specimen 1	Specimen 2
.505 Gage Specimen	48.6	49.8

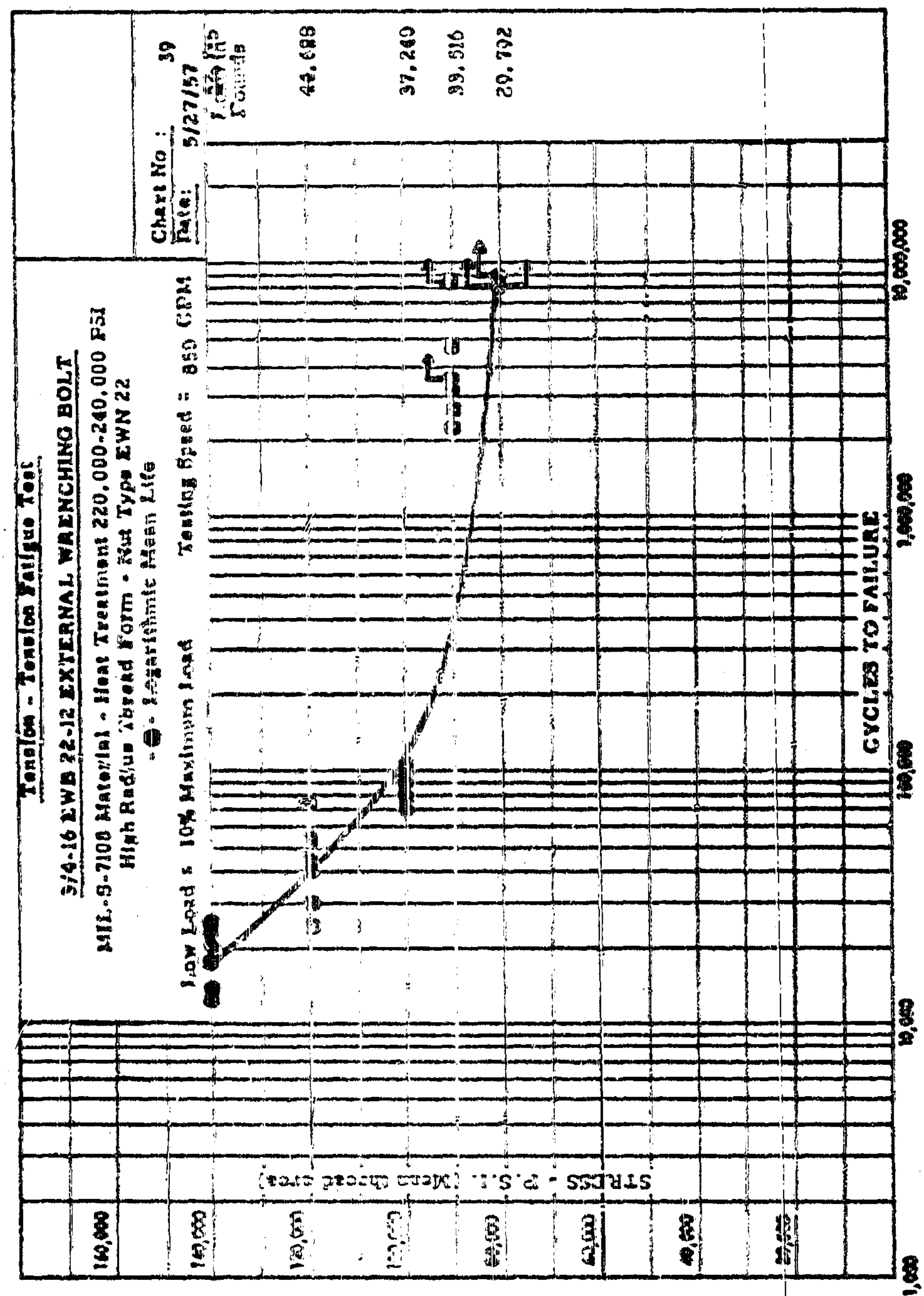
Shear Strength - Bolt Body

	Specimen 1	Specimen 2
Pounds - Double Shear	126,000	127,000
PSI	142,900	144,100

Fatigue Strength @ 8,000,000 Cycles 10% Low Load

Pounds	20,492
PSI (Mean Area)	55,000

Lot No. 85


Tension - Tension Fatigue Test
3/4-16 EWB 22-12 EXTERNAL WRENCHING BOLT
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
High Radius Thread Form - Nut Type EWN 22
Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 850 CPM
Chart No: 39
Date: 5/27/57
Pounds
44,688
37,240
33,516
29,792
STRESS - P.S.I. (Mean thread area)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 4-25-57

Bolt Design	**EWB 22-12**
Size	3/4-16
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	High Radius
Plate	Cadmium Fluoborate per NAS 672
Stress Area	.3724 Square inches
Nut Type	
Style	EWN 22
Material	AMS 6280
Heat Treatment	Rc 27-32
Testing Machine	
Make	Krouse
Capacity	60,000 pound
Speed	850 cpm

Maximum Load	52,136#	44,688#	37,240#
Stress	140,000 psi	120,000 psi	100,000 psi
	14,000	25,100	70,400
	14,600	30,100	76,600
	19,900	43,200	82,700
	21,100	54,300	91,700
	22,300	76,300	103,400
Average	18,380	45,800	84,960
Logarithmic Mean Life	18,050	42,260	83,800

Maximum Load	33,516#	29,792#
Stress	90,000 psi	80,000 psi
	2,332,300	8,872,400 NF
	2,637,000	8,451,200 NF
	3,500,000 NF	8,194,300 NF
	4,837,500	
	8,000,000 NF	
Average	4,261,560	8,506,000
Logarithmic Mean Life	3,838,000	8,506,000

MECHANICAL PROPERTIES

Date April 25, 1957 For Chart No. 39

Bolt Description

Type	EWB 22-12 High Radius
Size	3/4-16
Material	MIL-S-7108

Bolt Strength Pounds

	Specimen 1	Specimen 2
Ultimate Tensile	97,200	91,200
Yield Strength	67,000	70,000

Material Strength PSI

.505 Gage Specimen		
Tensile Strength	234,000	232,500
Yield Strength	193,000	190,000

Elongation - % in 4 Diameter

.505 Gage Specimen	13.2	14.0

Reduction of Area - %

.505 Gage Specimen	51.0	50.4

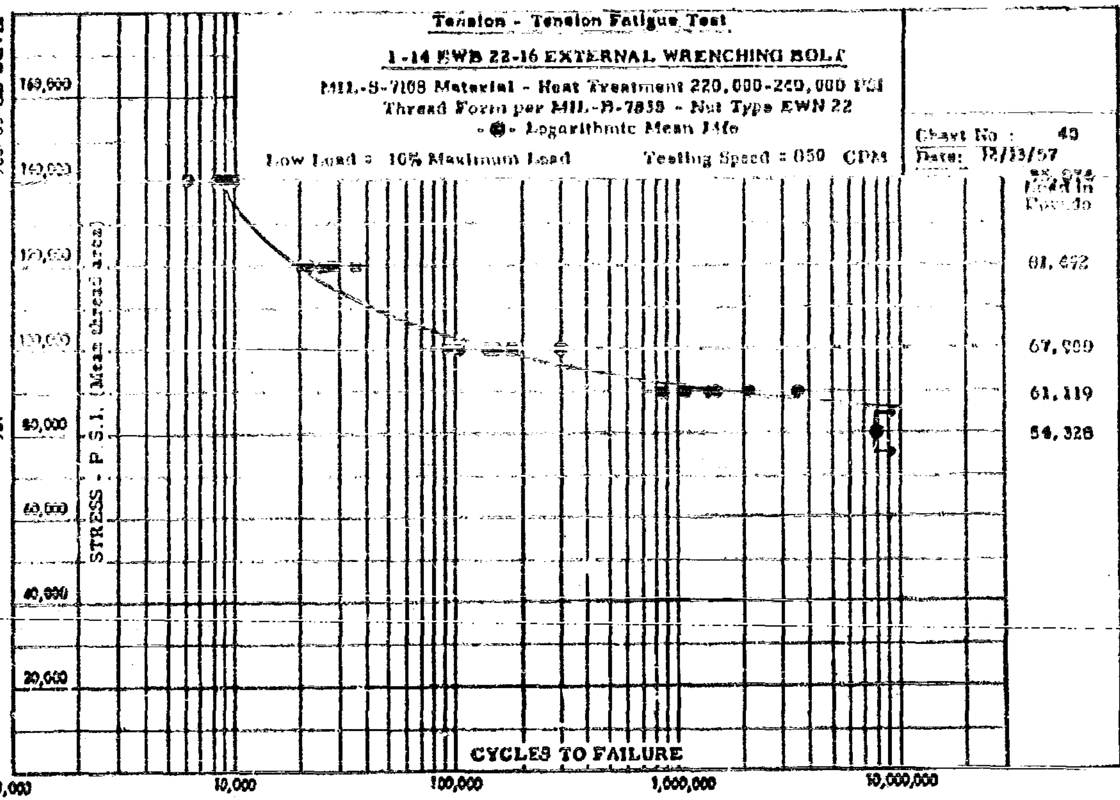
Shear Strength - Bolt Body

Pounds - Double Shear	123,000	125,000
PSI	139,500	141,800

Fatigue Strength @ 8,000,000 Cycles 10% Low Load

Pounds	29,792
PSI (Mean Area)	80,000

Lot No. 86


Tension - Tension Fatigue Test
1-14 EWB 22-16 EXTERNAL WRENCHING BOLT
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838 - Nut Type EWN 22
Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 050 CPM
Chart No : 49
Date: 12/13/57
Max. Load in Pounds
81,492
67,900
61,119
54,328
STRESS - P.S.I. (Mean thread area)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 12-13-57

Bolt Design	EWB 22-16
Size	1-14
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	Cadmium Fluoborate per NAS 672
Stress Area	0.67910 Square inches
Nut Type	
Style	EWN 22
Material	AMS 6280
Heat Treatment	Rc 27-32
Testing Machine	
Make	Amsler
Capacity	220,000 pound
Speed	500 cpm

Maximum Load	95,074#	81,492#	67,910#
Stress	140,000 psi	120,000 psi	100,000 psi
	6,200	22,300	115,300
	8,800	22,500	156,700
	9,300	27,000	95,200
	9,800	27,700	170,000
	10,200	37,300	300,000
Average	8,860	27,360	167,440
Logarithmic Mean Life	8,731	26,870	154,400

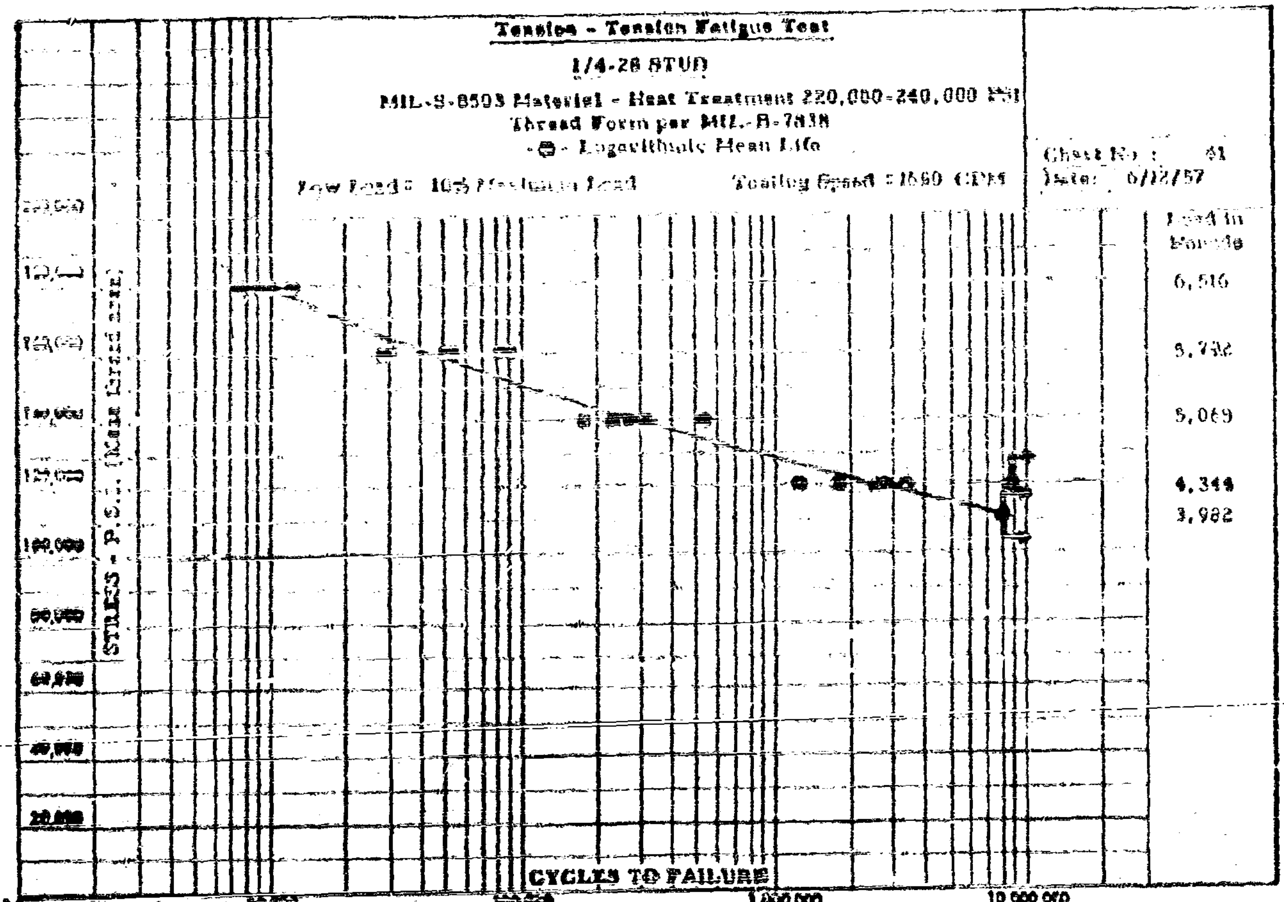
Maximum Load	61,119#	54,328#
Stress	90,000 psi	80,000 psi
	879,300	8,134,000
	1,121,000	8,032,000
	1,523,200	
	2,215,500	
	3,706,000	
Average	1,889,000	8,000,000
Logarithmic Mean Life	1,653,000	8,000,000

MECHANICAL PROPERTIES

Date November 8, 1957 For Chart No. 40

Bolt Description

Type	EWB 22 16	
Size	1-14	
Material	MIL-S-7108	
Bolt Strength Pounds		
	Specimen 1	Specimen 2
Ultimate Tensile	165,000	165,000
Yield Strength	126,000	126,000
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	243,000	230,000
Yield Strength	200,000	201,000
Elongation - % in 4 Diameter		
.505 Gage Specimen	15.6	15.65
Reduction of Area - %		
.505 Gage Specimen	49.6	49.2
Shear Strength - Bolt Body		
Pounds - Double Shear	207,000	209,500
PSI	131,800	133,400
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
~~Pounds~~	54,320	
PSI (Mean Area)	80,000	
Lot No.	778595131	


Tension - Tension Fatigue Test
1/4-28 STUD
MIL-S-8503 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
- Logarithmic Mean Life
Testing Speed = 1660 CPM
Chart No.: 41
Date: 6/12/57
Load in Pounds
6,516
5,069
4,344
3,982
STRESS - P.S.I. (Mean thread area)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 6-12-57

Bolt Design	Stud
Size	1/4-28
Material	MIL-S-8503
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	None
Stress Area	.0362 Square Inches
Nut Type	Unengaged
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1650 cpm

Maximum Load	6,516#	5,792#	5,068#
Stress	180,000 psi	160,000 psi	140,000 psi
	9,000	29,500	301,300
	10,000	91,300	183,400
	7,600	28,700	244,200
	7,800	53,200	253,500
	12,000	84,400	535,600
Average	9,201	57,420	303,600
Logarithmic Mean Life	9,201	51,060	284,900

Maximum Load	4,344#	3,982#
Stress	120,000 psi	110,000 psi
	1,301,900	8,123,000 NF
	1,701,600	8,123,000 NF
	2,618,800	
	3,170,000	
	8,900,000	
Average	3,538,400	8,123,000
Logarithmic Mean Life	2,772,000	8,123,000

MECHANICAL PROPERTIES

Date June 10, 1957 **For Chart No.** 41

Bolt Description

Type	Stud	
Size	1/4-28	
Material	MIL-S-8503	

Bolt Strength Pounds

	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		

Material Strength PSI

	Specimen 1	Specimen 2
.113 Gage Specimen		
Tensile Strength	236,500	237,500
Yield Strength	222,500	215,000

Elongation - % in 4 Diameter

	Specimen 1	Specimen 2
.113 Gage Specimen	11.5	11.5

Reduction of Area - %

	Specimen 1	Specimen 2
.113 Gage Specimen	44.7	44.7

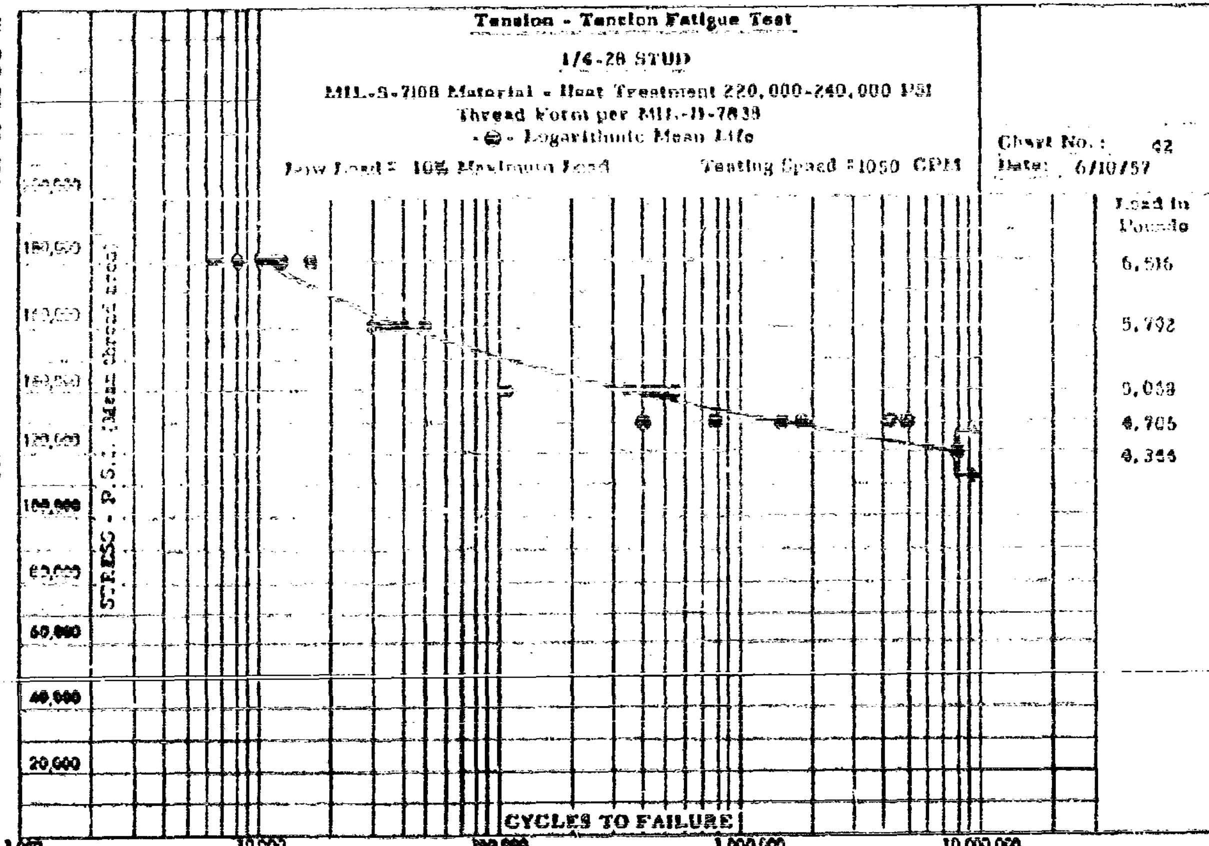
Shear Strength - Bolt Body

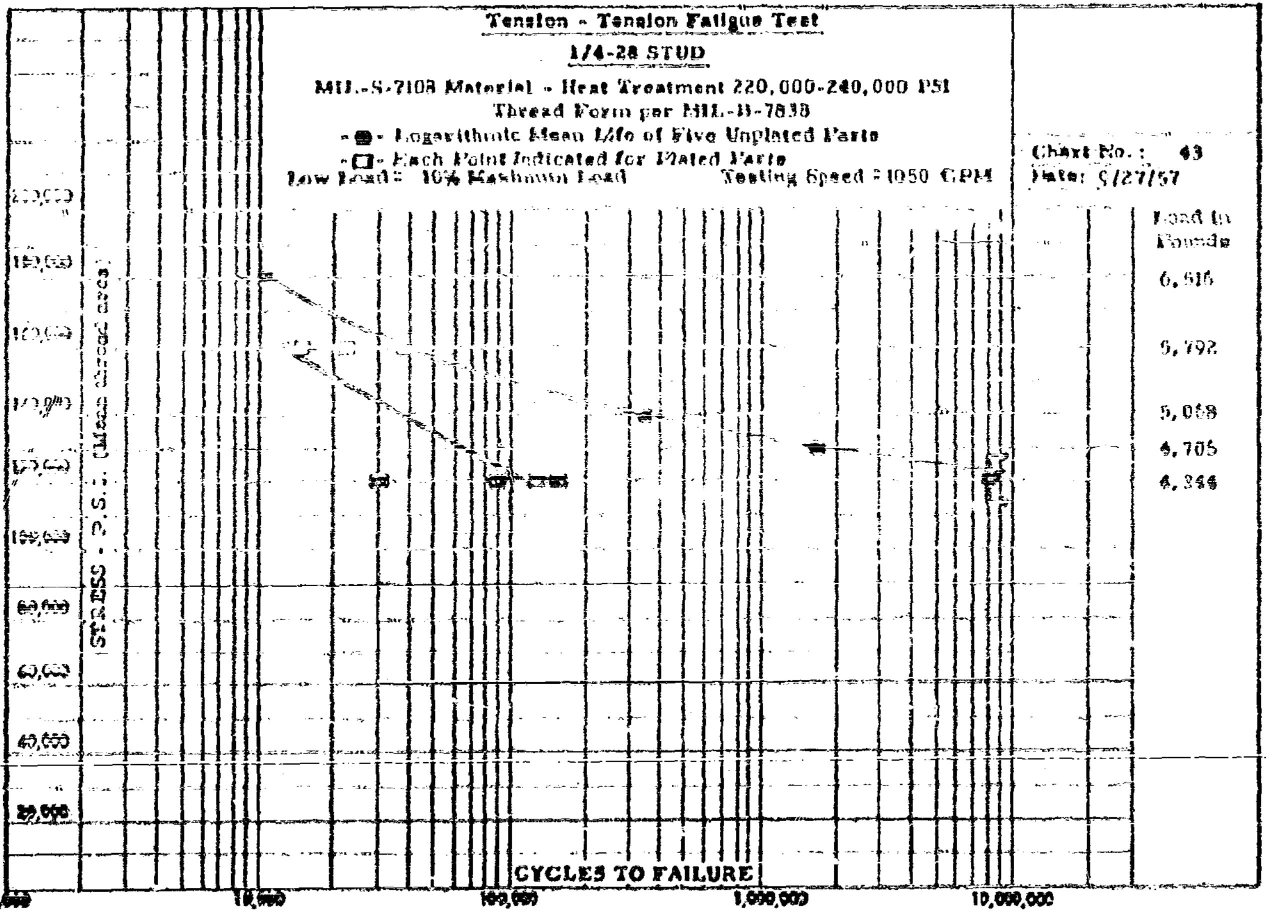
Pounds - Double Shear	
PSI	

Fatigue Strength @ 8,000,000 Cycles 10% Low Load

Pounds	3,982
PSI (Mean Area)	110,000

Lot No. 173


Tension - Tension Fatigue Test
1/4-28 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
- ⊖ - Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed =1050 CPM
Chart No.: 42
Date: 6/10/57
Load in Pounds
6,516
5,792
5,068
4,705
4,344
STRESS - P.S.I. (Mean thread area)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000


Tension - Tension Fatigue Test
1/4-28 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
- Logarithmic Mean Life of Five Unplated Parts
- Each Point Indicated for Plated Parts
Low Load: 10% Maximum Load
Testing Speed 1050 CPM
Chart No.: 43
Date: 5/27/57
Load in Pounds
6,616
5,792
5,058
4,705
4,344
STRESS - P.S.I. (Mean thread area)
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 6-10-57

Bolt Design	Stud
Size	1/4-28
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	None
Stress Area	.0362 Square inches
Nut Type	Unengaged
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1050 cpm

Maximum Load	6,516#	5,792#		5,068#
Stress	180,000 psi	160,000 psi		140,000 psi
		Unplated	Plated	
	16,400	50,500	12,100	363,200
	12,100	38,100	13,800	463,900
	11,600	33,700	16,300	460,000
	8,100	32,100	22,700	425,000
	6,400	31,900		104,100
Average	10,920	37,260	16,230	403,200
Logarithmic Mean Life	10,360	36,680	15,770	350,900

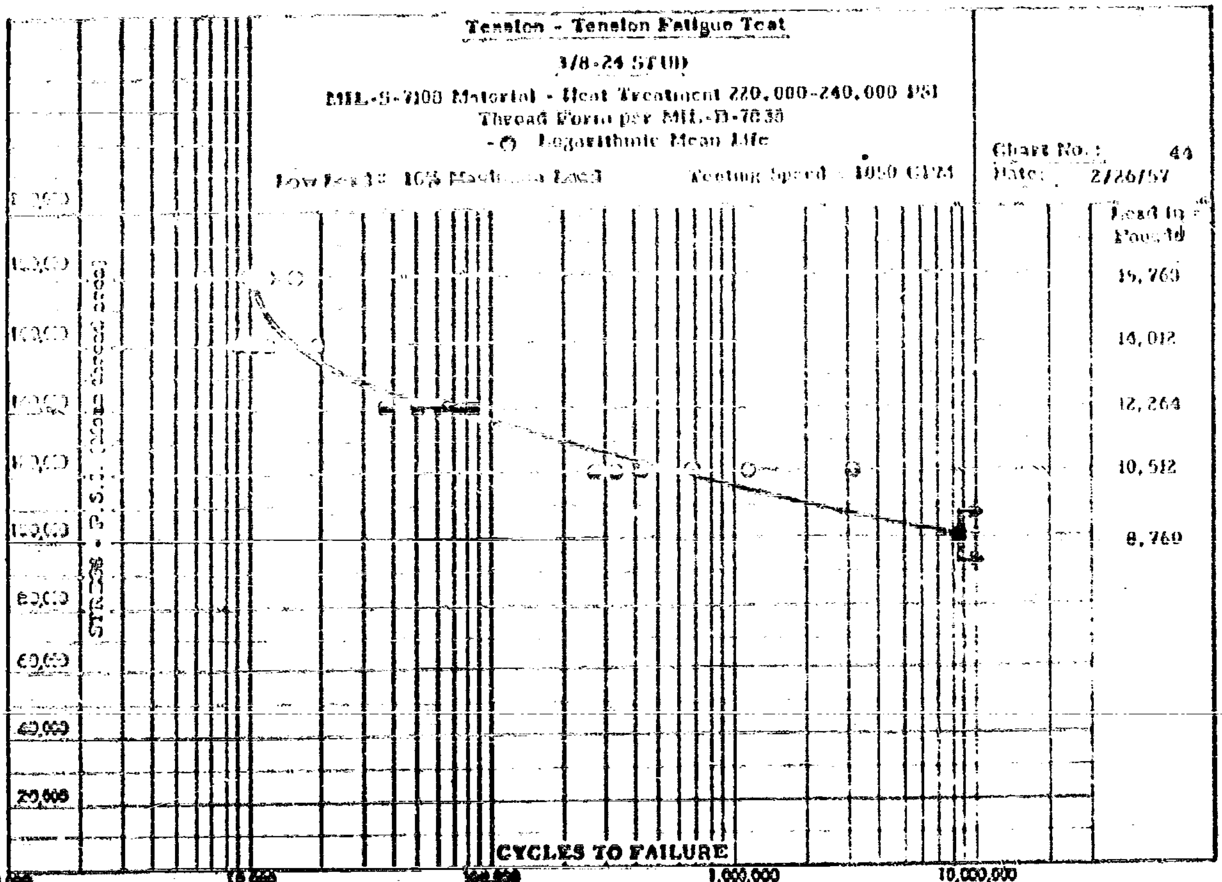
Maximum Load	4,706#	4,344#	
Stress	130,000 psi	120,000 psi	
		Unplated	Plated
	399,600	9,115,900 NF	30,300
	4,470,000	9,115,900 NF	89,900
	787,500		138,700
	4,981,000		160,200
	1,823,000		
Average	2,492,200	9,115,900	104,780
Logarithmic Mean Life	1,642,000	9,115,900	88,200

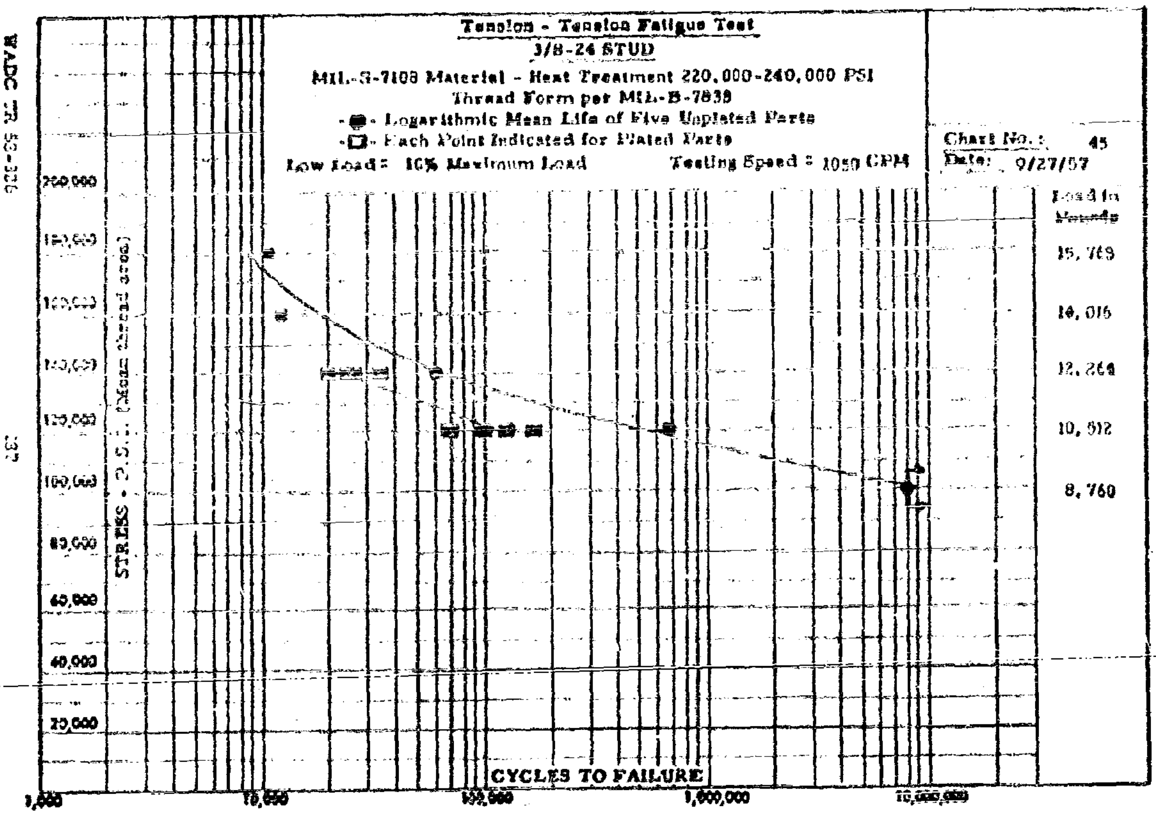
MECHANICAL PROPERTIES

Date March 14, 1957 For Chart No. 42

Bolt Description

Type	Stud	
Size	1/4-28	
Material	MIL-S-7108	
Bolt Strength Pounds		
	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.113 Gage Specimen		
Tensile Strength	227,300	231,700
Yield Strength	207,300	297,700
Elongation - % in 4 Diameter		
.113 Gage Specimen	11.5	12.1
Reduction of Area - %		
.113 Gage Specimen	52.1	53.9
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	4,344	
PSI (Mean Area)	120,000	
Lot No.	75	


Tension - Tension Fatigue Test
3/8-24 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
-O Logarithmic Mean Life
Testing Speed 1050 CPM
Chart No.: 44
Date: 2/26/57
Load in Pounds
15,760
14,012
12,264
10,512
8,760
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000



Tension - Tension Fatigue Test
3/8-24 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
- Logarithmic Mean Life of Five Unplated Parts
- Each Point Indicated for Plated Parts
Low Load = 10% Maximum Load
Testing Speed = 1050 CPM
Chart No.: 45
Date: 9/27/57
Load in Pounds
15,769
14,016
12,264
10,512
8,760
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 2-26-57

Bolt Design	**Stud**
Size	3/8-24
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	None
Stress Area	.0876 Square Inches
Nut Type	Unengaged
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Krouse
Capacity	15,000 pound
Speed	1050 cpm

Maximum Load	15,768#	14,016#	12,264#	
Stress	180,000 psi	160,000 psi	140,000 psi	
			Unplated	Plated
	15,000	20,000	81,000	20,300
	11,100	11,400	80,700	24,200
	10,200	11,400	74,700	26,300
	9,800	10,000	51,100	27,100
	6,500	9,600	38,400	33,800
Average	10,520	12,480	65,480	26,340
Logarithmic Mean Life	10,160	12,010	62,560	25,860

Maximum Load	10,512#		8,760#
Stress	120,000 psi		100,000 psi
	Unplated	Plate	
	3,136,900	69,800	8,067,300
	1,375,000	97,400	8,067,300
	492,300	128,300	
	307,400	172,100	
	286,400		
Average	1,101,600	116,900	8,067,300
Logarithmic Mean Life	686,800	110,700	8,067,300

MECHANICAL PROPERTIES

Date February 26, 1957 **For Chart No.** 44

Bolt Description

Type	Stud
Size	3/8-24
Material	MIL-S-7108

Bolt Strength Pounds

	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.252 Gage Specimen		
Tensile Strength	227,600	224,000
Yield Strength	191,300	197,500
Elongation - % in 4 Diameter		
.252 Gage Specimen	13.0	13.0
Reduction of Area - %		
.252 Gage Specimen	53.5	55.6

Shear Strength - Bolt Body

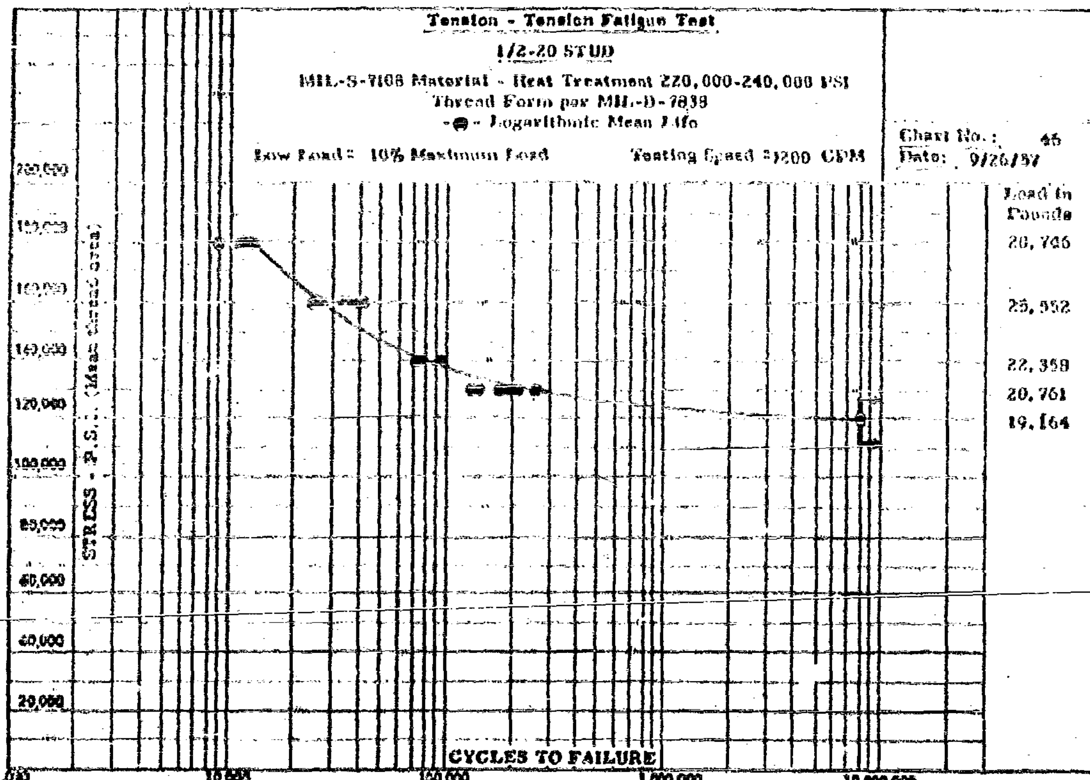
Pounds - Double Shear

PSI

Fatigue Strength @ 8,000,000 Cycles 10% Low Load

Pounds	8,760
PSI (Mean Area)	100,000

Lot No. 53


Tension - Tension Fatigue Test
1/2-20 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed 3200 CPM
Chart No.: 46
Date: 9/26/57
Load in Pounds
28,746
25,552
22,358
20,761
19,164
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
1,000
10,000
100,000
1,000,000
10,000,000
CYCLES TO FAILURE

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 9-26-57

Bolt Design — Stud
- Size — 1/2-20
- Material — MIL-S-7108
- Heat Treatment — 220,000-240,000 psi
- Thread Form — MIL-B-7838
- Plate — None

Stress Area — .1597 Square Inches

Nut Type — Unengaged
- Style
- Material
- Heat Treatment

Testing Machine
- Make — Ivy
- Capacity — 60,000 pound
- Speed — 1200 cpm

Maximum Load	28,746#	25,552#	22,358#
Stress	180,000 psi	160,000 psi	140,000 psi
	9,200	25,200	74,000
	10,860	27,600	76,000
	10,900	34,800	79,100
	11,080	41,000	80,500
	13,000	41,000	95,300
Average	10,980	33,920	80,980
Logarithmic Mean Life	10,910	33,240	80,550

Maximum Load	20,761#	19,164#
Stress	130,000 psi	120,000 psi
	122,000	8,431,000
	126,000	8,306,000
	196,000	8,640,000
	208,000	
	270,000	
Average	184,400	8,000,000
Logarithmic Mean Life	176,100	8,000,000

MECHANICAL PROPERTIES

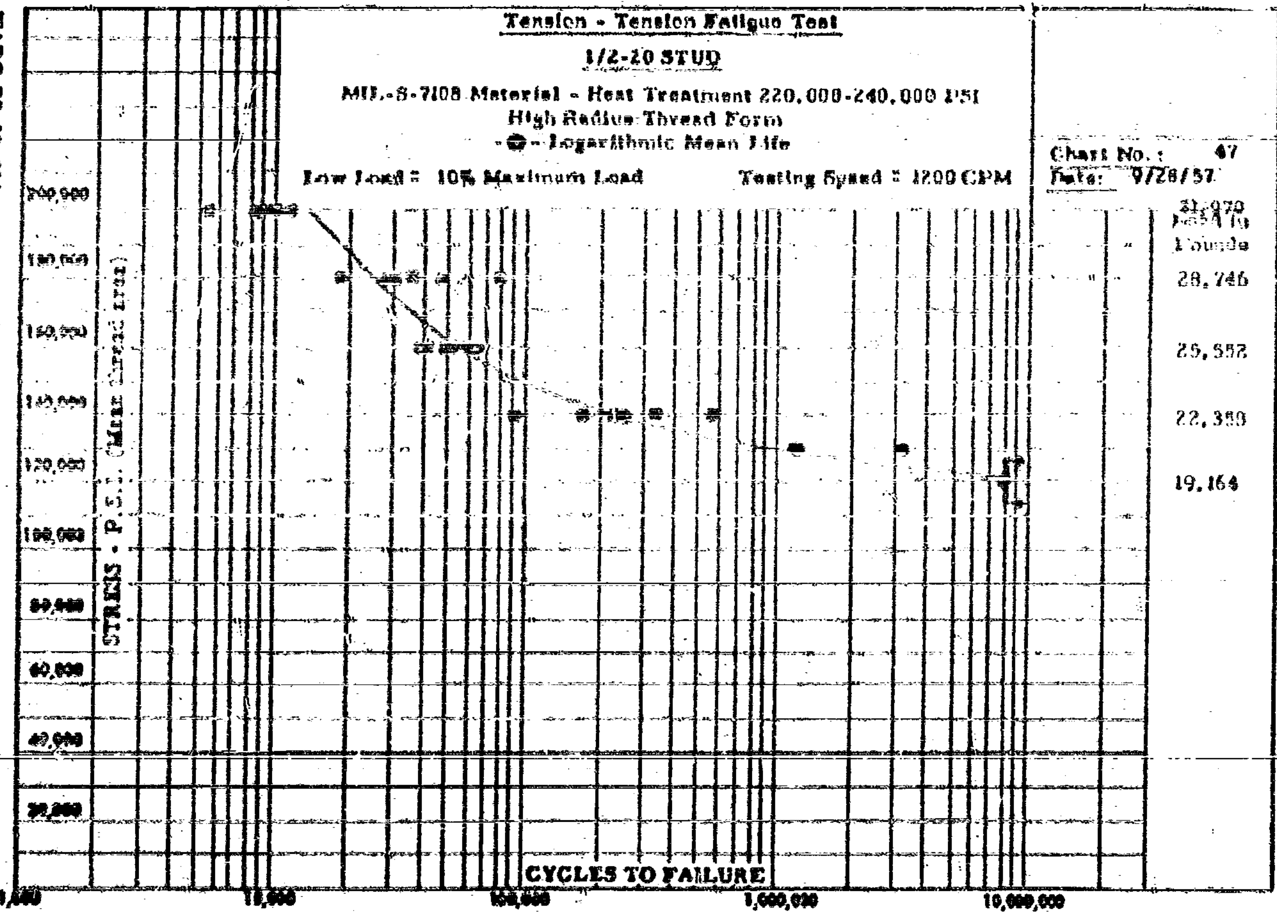
Date May 8, 1957 For Chart No. 45

Bolt Description

Type	Stud
Size	1/2-20 MIL-B Thread
Material	MIL-S-7108

Bolt Strength Pounds

	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.357 Gage Specimen		
Tensile Strength	232,000	230,000
Yield Strength	200,000	205,000
Elongation - % in 4 Diameter		
.357 Gage Specimen	11.6	10.6
Reduction of Area - %		
.357 Gage Specimen	47.0	46.1
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	19,164	
PSI (Mean Area)	120,000	
Lot No.	81	


Tension - Tension Fatigue Test
1/2-20 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
High Radius Thread Form
-⊖- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No.: 47
Date: 9/26/57
31,070
Load in
Pounds
28,746
25,552
22,350
19,164
STRESS - P.S.I. (Mean Thread Area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 9-28-56

Bolt Design	Stud
Size	1/2-20
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	High Radius
Plate	None
Stress Area	0.1597 Square Inches
Nut Type	
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Ivy
Capacity	60,000 pound
Speed	1200 CPM

Maximum Load	31,970#	28,740#	25,552#
Stress	200,000 psi	180,000 psi	160,000 psi
	5,500	19,800	40,700
	8,700	28,000	41,000
	9,600	31,600	54,500
	10,100	47,300	60,500
	11,200	81,500	63,200
Average	9,020	41,640	52,180
Logarithmic Mean Life	[illegible]	[illegible]	[illegible]

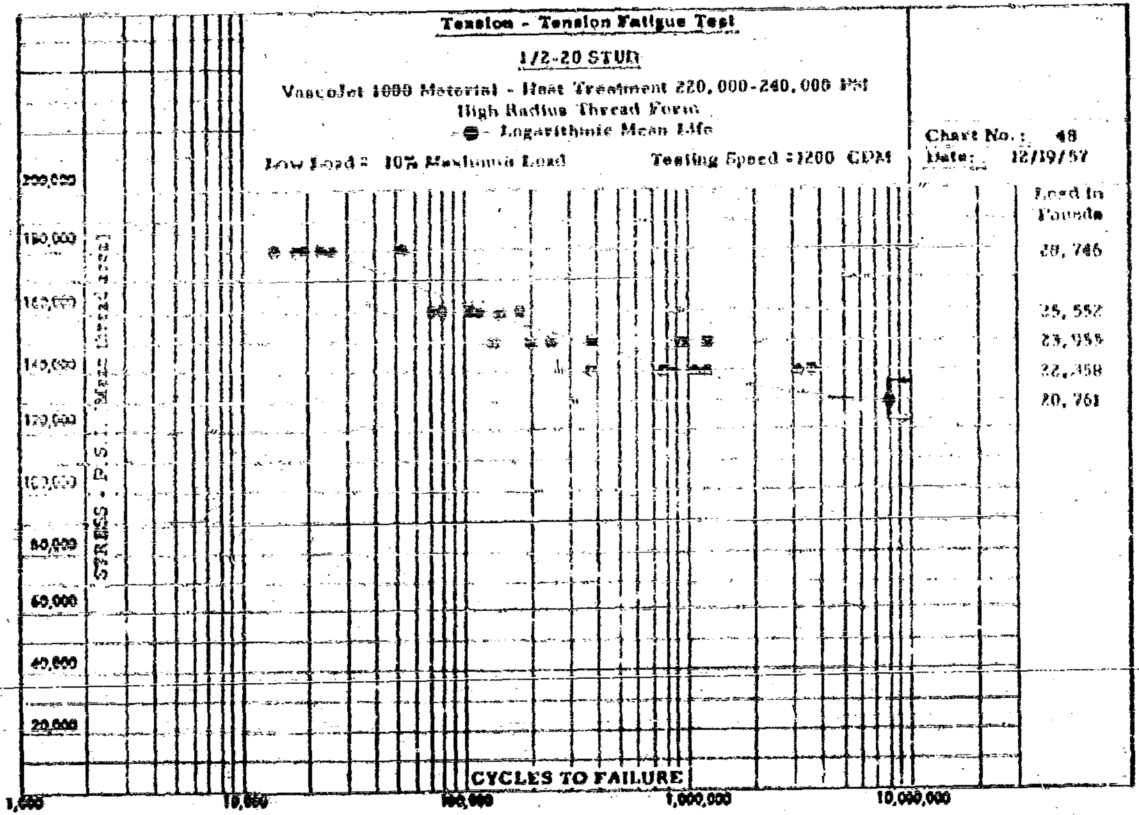
Maximum Load	22,358#	20,761#	19,164#
Stress	140,000 psi	130,000 psi	120,000 psi
	93,400	1,386,000	8,500,000 NF
	165,300	3,315,700	8,200,000 NF
	251,600		
	348,000		
	576,000		
Average	286,900	2,351,000	8,350,000
Logarithmic Mean Life	238,900		

MECHANICAL PROPERTIES

Date May 8, 1957 For Chart No. 47

Bolt Description

Type	Stud	
Size	1/2-20 High Radius	
Material	MIL-S-7108	
Bolt Strength Pounds		
	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.357 Gage Specimen		
Tensile Strength	232,000	230,000
Yield Strength	200,000	205,000
Elongation - % in 4 Diameter		
.357 Gage Specimen	11.6	10.6
Reduction of Area - %		
.357 Gage Specimen	47.0	46.1
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	19,164	
~~PSI (Mean Area)~~	~~120,000~~	
Lot No.	82	



Tension - Tension Fatigue Test
1/2-20 STUD
VascoJet 1000 Material - Heat Treatment 220,000-240,000 PSI
High Radius Thread Form
- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No.: 48
Date: 12/19/57
Load in Pounds
28,746
25,552
23,955
22,358
20,761
STRESS - P.S.I. Major Thread Area
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 12-19-57

Bolt Design	Stud
Size	1/2-20
Material	VascoJet 1000
Heat Treatment	220,000-240,000 psi
Thread Form	High Radius
Plate	None
Stress Area	.1597 Square inches
Nut Type	None
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Ivy
Capacity	60,000 pound
Speed	1200 cpm

Maximum Load	28,746#	25,552#	23,955#
Stress	180,000 psi	160,000 psi	150,000 psi
	15,000	72,000	984,000
	19,000	80,000	134,000
	18,000	108,000	192,000
	24,000	142,000	227,000
	54,000	184,000	1,318,000
Average	26,000	117,000	571,000
Logarithmic Mean Life	21,150	110,000	376,600

Maximum Load	22,358#	20,761#
Stress	140,000 psi	130,000 psi
	387,000	38,523,000 NF
	~~761,700~~	~~16,044,000 NF~~
	1,104,300	8,119,000 NF
	3,221,000	
	3,361,000	
Average	1,767,000	8,000,000
Logarithmic Mean Life	1,287,000	8,000,000

MECHANICAL PROPERTIES

Date December 28, 1957 **For Chart No.** 48

Bolt Description

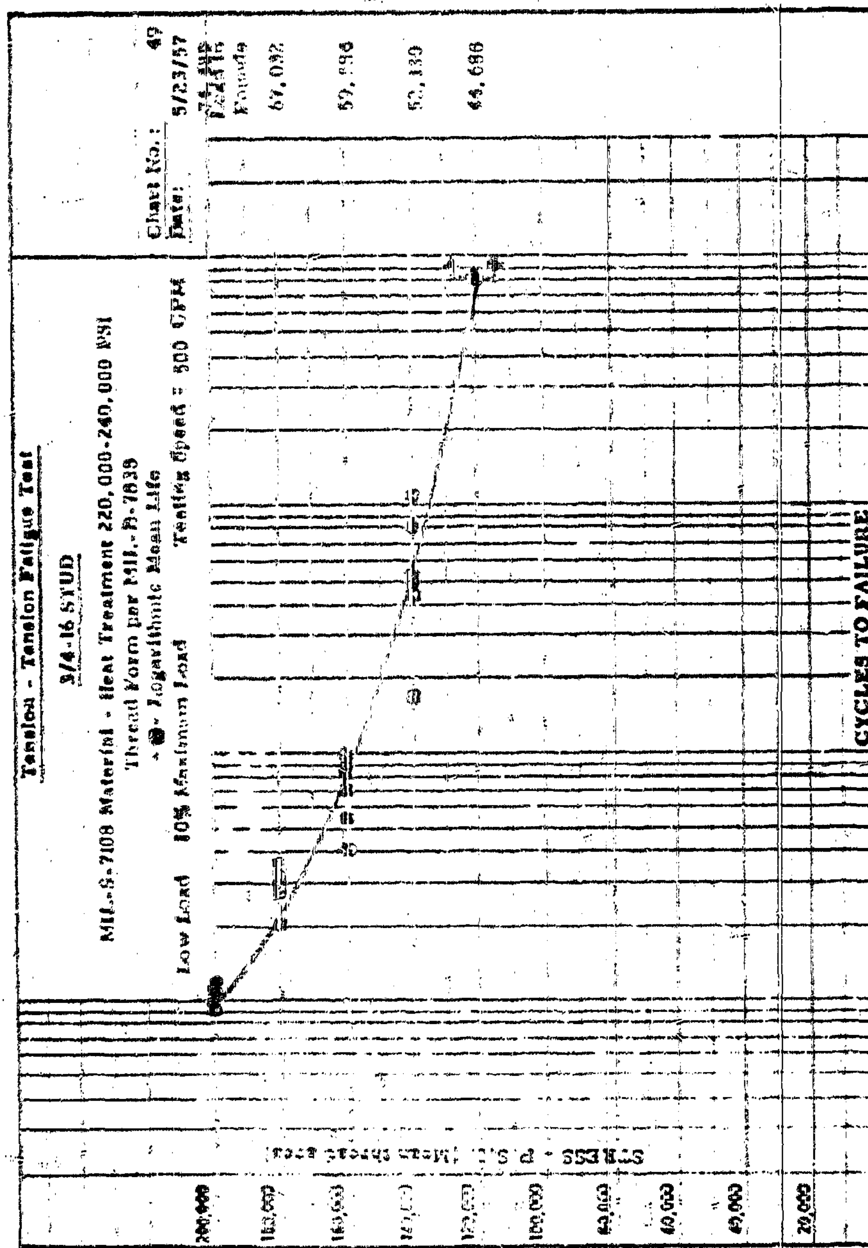
Type	Stud
Size	1/2-20
Material	VascoJet 1000

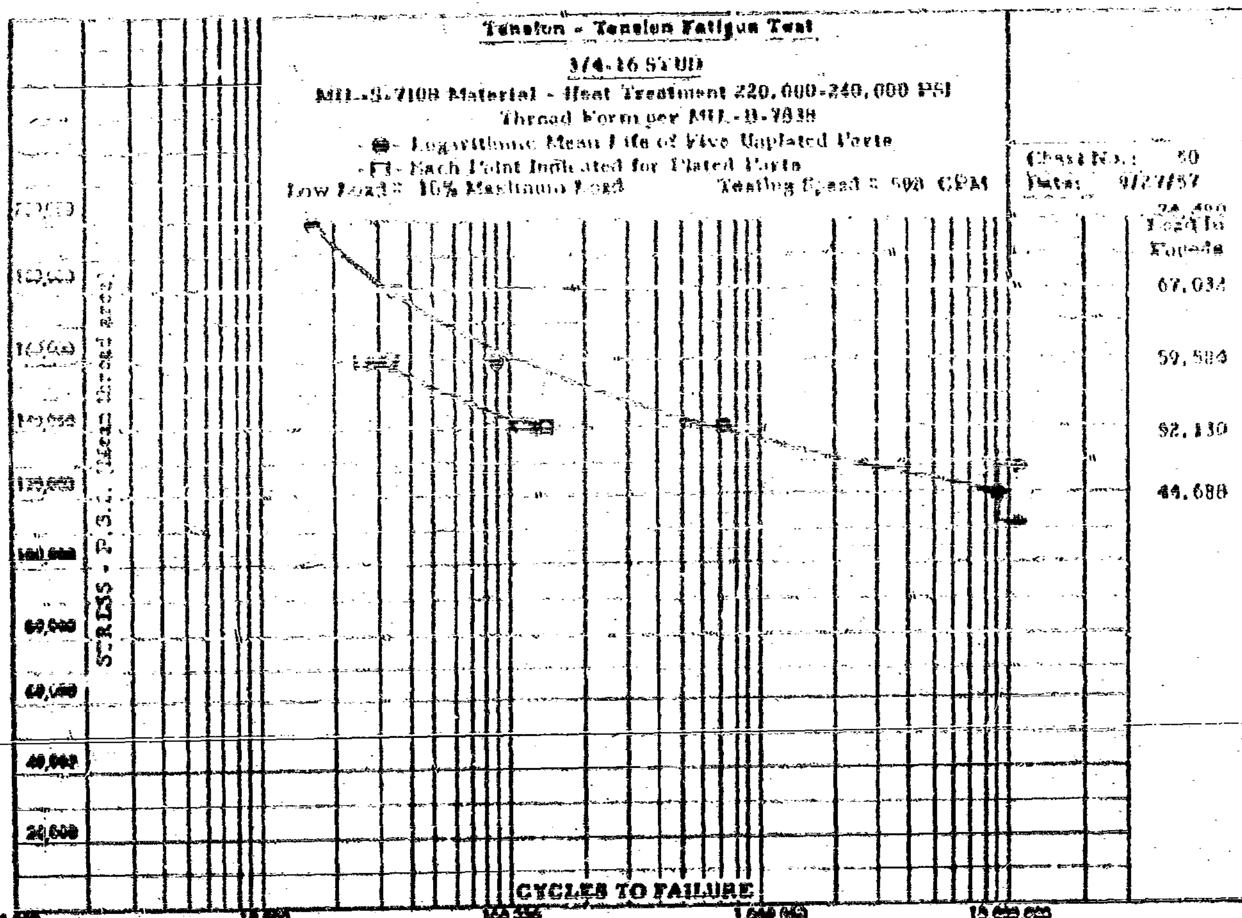
	Specimen 1	Specimen 2	Specimen 3
Bolt Strength Pounds			
Ultimate Tensile			
Yield Strength			
Material Strength PSI			
.357 Gage Specimen			
Tensile Strength	238,360	234,900	239,200
Yield Strength	196,300	194,600	202,100
Elongation - % in 4 Diameter			
.357 Gage Specimen	12.8	12.0	12.6
Reduction of Area - %			
.357 Gage Specimen	48.9	46.8	48.6
Shear Strength - Bolt Body			
Pounds - Double Shear			
PSI			

Fatigue Strength @ 8,000,000 Cycles 10% Low Load

Pounds	20,671
PSI (Mean Area)	130,000

Lot No. 529


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
- ⊕ - Logarithmic Mean Life
Low Load 10% Maximum Load
Testing Speed = 500 CPM
Chart No.: 49
Date: 5/23/57
Pounds
67,092
59,596
52,130
44,696
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
1,000
10,000
100,000
1,000,000
10,000,000
CYCLES TO FAILURE


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
- Logarithmic Mean Life of Five Unplated Parts
- Each Point Indicated for Plated Parts
Low Load = 10% Maximum Load
Testing Speed = 500 CPM
Chart No.: 50
Date: 9/27/57
Load In Pounds
67,034
59,584
52,130
44,680
STRESS - P.S.I. (Mean thread area)
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 5-28-57

Bolt Design	Stud
Size	3/4-16
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	None
Stress Area	.3724 Square Inches
Nut Type	Unengaged
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Amsler
Capacity	220,000 pound
Speed	500 cpm

Maximum Load	74,480#	67,032#	59,584#	
Stress	200,000 psi	180,000 psi	160,000 psi	
			Unplated	Plated
	9,600	20,500	54,900	20,200
	10,400	31,500	80,800	23,100
	9,500	36,400	40,500	23,600
	10,300	32,000	96,200	25,000
	10,100	28,400	82,600	28,700
Average	10,020	29,740	72,600	24,280
Logarithmic Mean Life	9,970	29,200	69,040	24,140

Maximum Load	52,136#		44,688#
Stress	140,000 psi		120,000 psi
	Unplated	Plated	
	1,175,900	40,900	8,046,000 NF
	521,200	57,200	8,046,000 NF
	172,000	63,100	
	444,000	90,400	
	823,100		
Average	627,220	62,900	8,046,000
Logarithmic Mean Life	521,400	60,440	8,046,000

Area

7

47,500#
160,000 psi

Deplated	Plated
54,900	20,200
80,800	23,100
43,500	23,400
95,200	25,800
82,400	28,700
72,600	24,280
69,040	24,140

44,688#
± 20,000 psi

8,046,000 NF
8,046,000 NF

8,046,000

8,046,000

MECHANICAL PROPERTIES

Date May 28, 1957 For Chart No. 49

Bolt Description

Type	Stud
Size	3/4-16 MIL-B Thread
Material	MIL-S-7108

	Specimen 1	Specimen 2
Bolt Strength Pounds		
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	250,000	237,500
Yield Strength	220,000	212,000
Elongation - % in 4 Diameter		
.505 Gage Specimen	14.0	15.0
Reduction of Area - %		
.505 Gage Specimen	49.2	45.1
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	44,688	
PSI (Mean Area)	120,000	
Lot No.	78	

MECHANICAL PROPERTIES

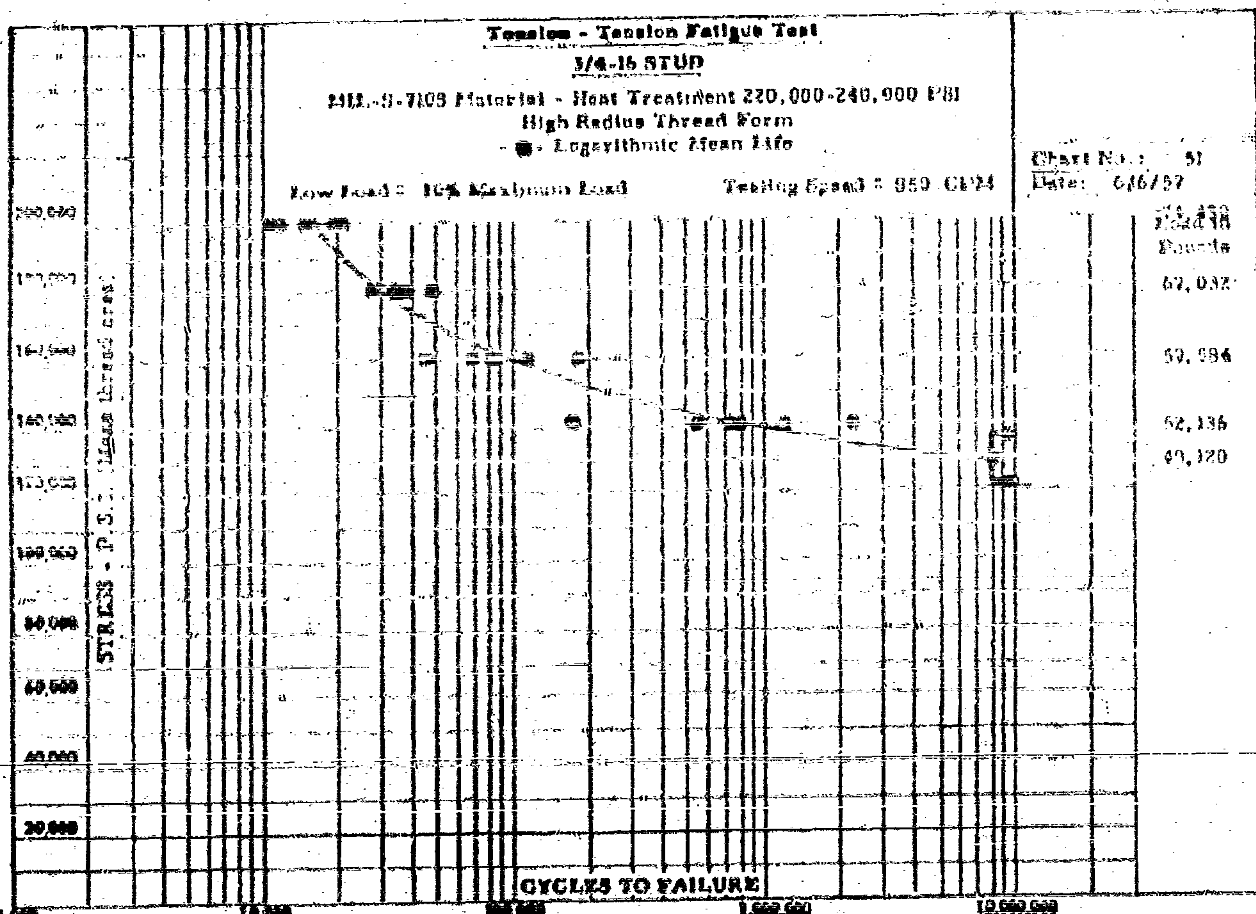
Date May 28, 1957 For Chart No. 49

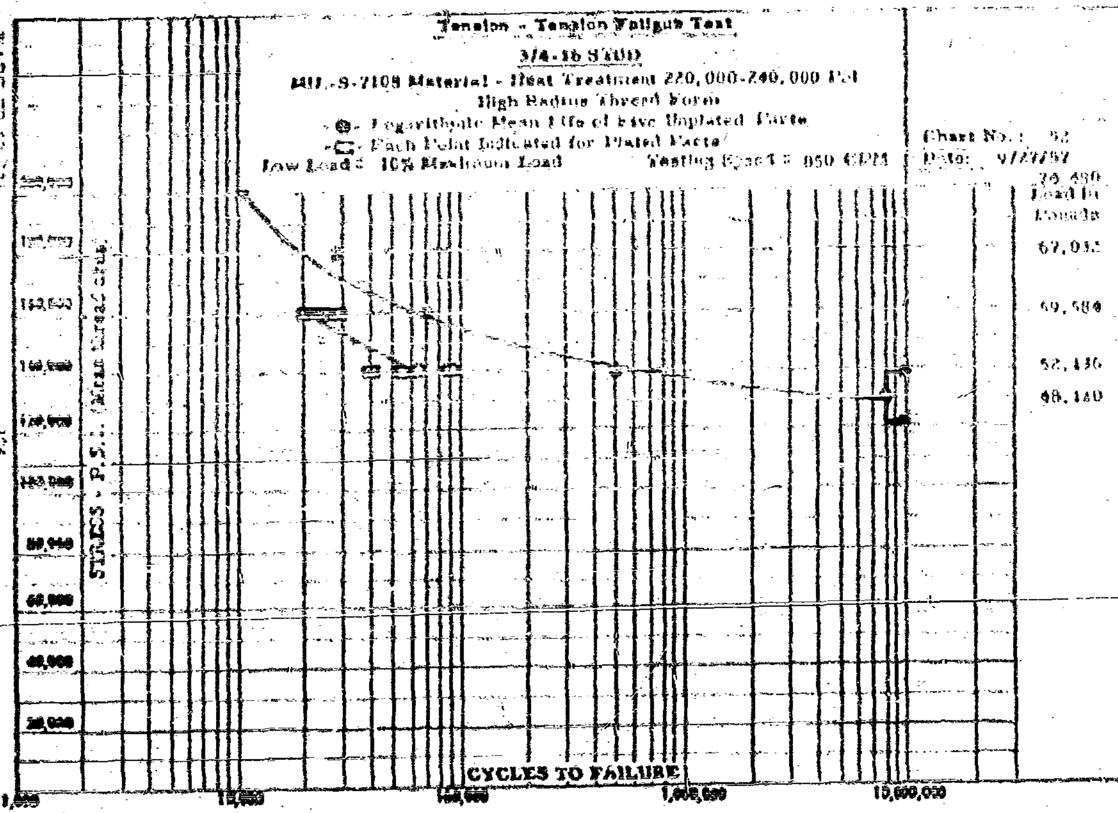
Bolt Description

Type	Stud	
Size	3/4-16 MIL-B Thread	
Material	MIL-S-7108	

Bolt Strength Pounds

	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	250,000	247,500
Yield Strength	220,000	212,000
Elongation - % in 4 Diameter		
.505 Gage Specimen	13.0	15.0
Reduction of Area - %		
.505 Gage Specimen	49.2	45.1
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	44,698	
PSI (Mean Area)	120,000	
Lot No.	78	


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-7105 Material - Heat Treatment 220,000-240,000 PSI
High Radius Thread Form
- Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 950 CPM
Chart No.: 51
Date: 6/6/57
Load in Pounds
67,032
59,984
52,136
49,120
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-7105 Material - Heat Treatment 220,000-240,000 PSI
High Radius Thread Form
Logarithmic Mean Life of Five Unplated Parts
Each Point Indicated for Plated Parts
Low Load = 10% Maximum Load
Testing Speed = 850 CPM
Chart No.: 92
Load In Pounds
67,032
60,580
52,136
48,140
STRESS - P.S.I. (Mean thread area)
200,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 6-6-57

Bolt Design	Stud
Size	3/4-16
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	High Radius
Plate	None
Stress Area	0.3724 square inches
Nut Type	Unengaged
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Krouse
Capacity	60,000 pound
Speed	850 cpm

Maximum Load	74,480#	67,032#	59,584#	
Stress	200,000 psi	180,000 psi	160,000 psi	
			Unplated	Plated
	11,200	49,900	180,600	20,200
	11,300	39,500	85,600	23,100
	29,600	27,100	46,800	23,600
	21,000	36,300	69,700	25,800
	15,200	30,200	111,300	28,700
Average	15,860	36,400	98,800	24,280
Logarithmic Mean Life	15,280	35,590	89,890	24,140

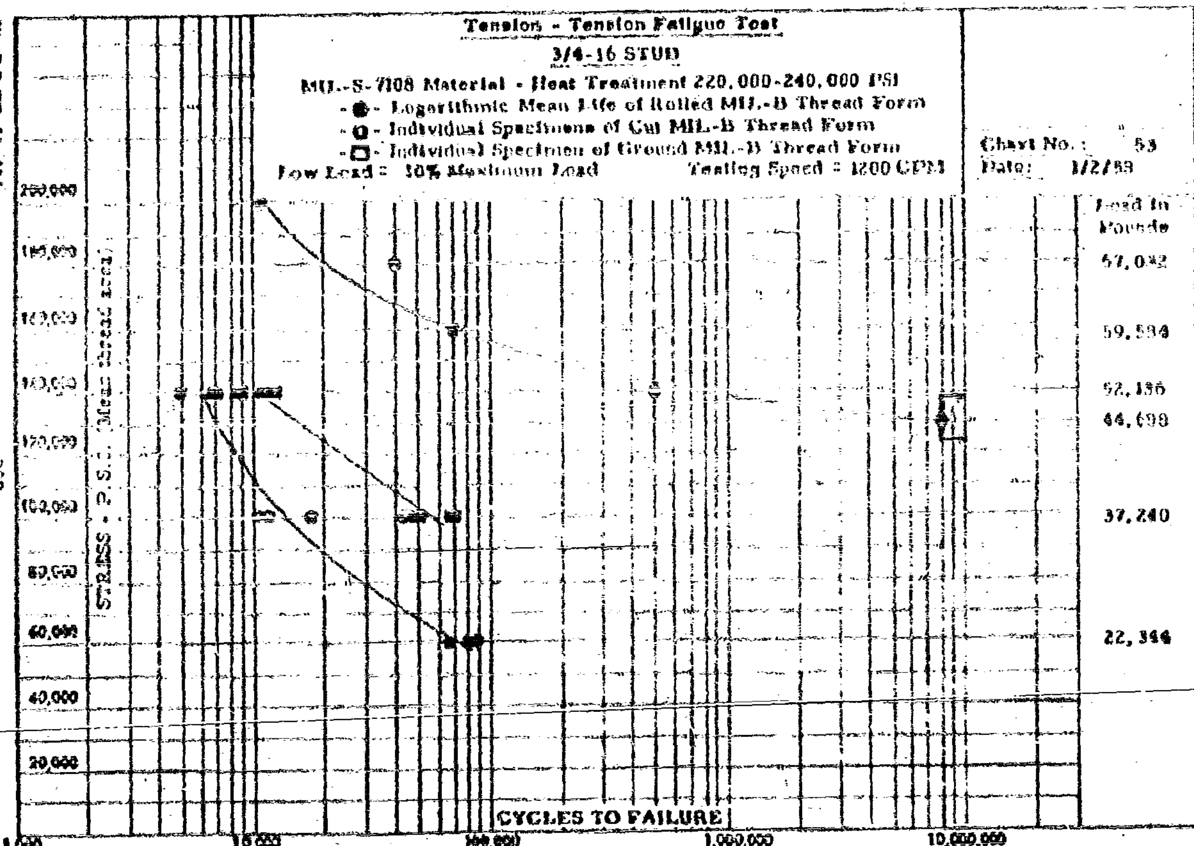
Maximum Load	52,136#		48,120#
Stress	140,000 psi		130,000 psi
	Unplated	Plated	
	2,313,000	40,900	8,043,000 NF
	168,000	57,200	8,043,000 NF
	1,340,000(Body)	63,100	
	785,000	90,400	
	562,700		
Average	1,033,.00	62,900	8,043,000
Logarithmic Mean Life	745,300	60,440	8,043,000

MECHANICAL PROPERTIES

Date May 28, 1957 **For Chart No.** 51 and 52

Bolt Description

Type	Stud	
Size	3/4-16 High Radius	
Material	MIL-S-7108	
Bolt Strength Pounds	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	250,000	237,500
Yield Strength	220,000	212,000
Elongation - % in 4 Diameter		
.505 Gage Specimen	14.0	15.0
Reduction of Area - %		
.505 Gage Specimen	49.2	45.1
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds	48,120	
PSI (Mean Area)	130,000	
Lot No.	49	


Tension - Tension Fatigue Test
3/4-16 STUD
MIL-S-7108 Material - Heat Treatment 220,000-240,000 PSI
- Logarithmic Mean Life of Rolled MIL-B Thread Form
- Individual Specimens of Cut MIL-B Thread Form
- Individual Specimen of Ground MIL-B Thread Form
Low Load = 10% Maximum Load
Testing Speed = 1200 CPM
Chart No.: 53
Date: 1/2/53
Load in Pounds
67,032
59,584
52,136
44,698
37,240
22,344
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
STRESS - P.S.I. (Mean thread area)
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 1-2-58

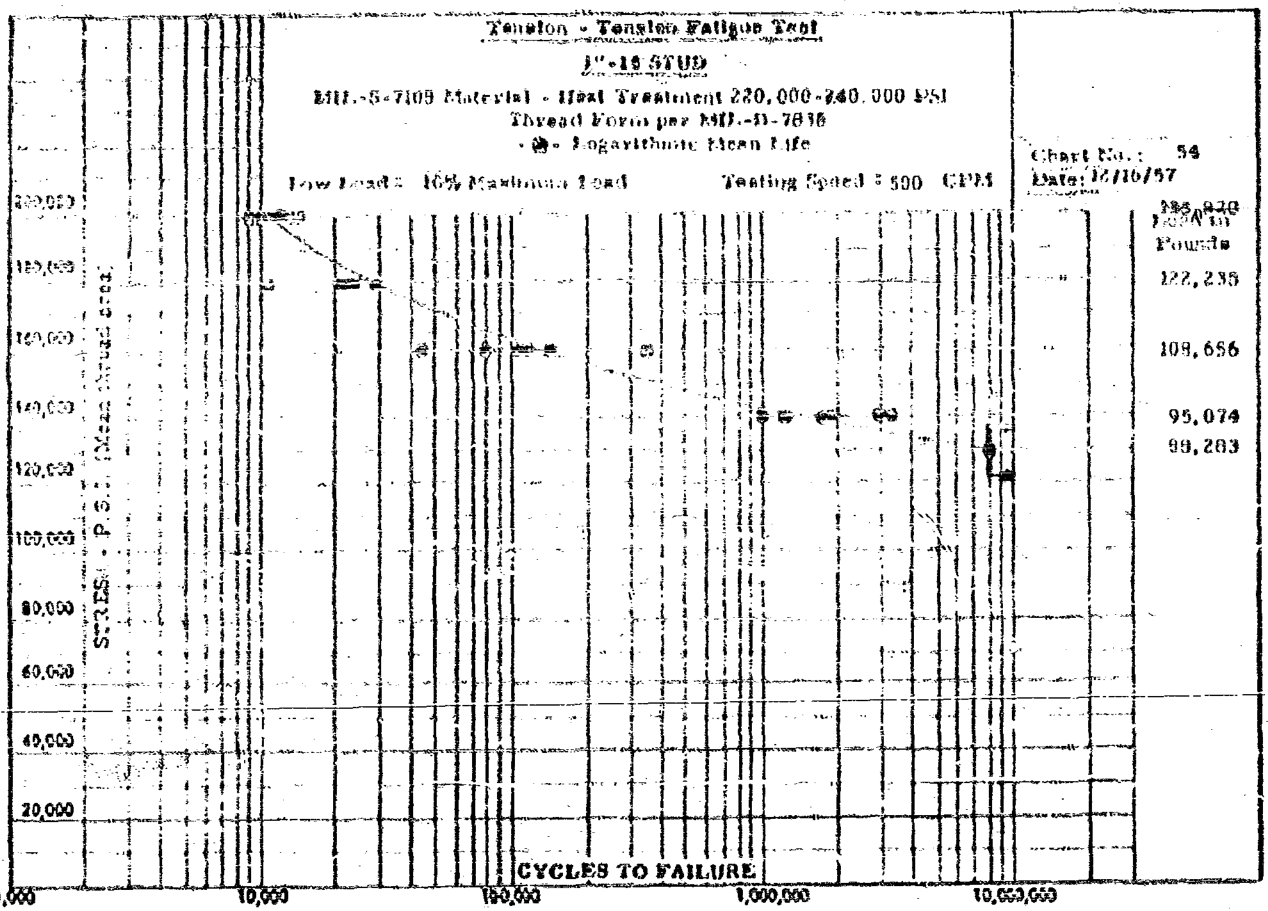
Bolt Design	Stud	Stud
Size	3/4-16	3/4-16
Material	MIL-S-7108	MIL-S-7108
Heat Treatment	220,000-240,000 psi	220,000-240,000 psi
Thread Form	Cut UNF 3A	Ground MIL-B
Plate	None	None
Stress Area	.3724 Square Inches	
Nut Type	Unengaged	Unengaged
Style		
Material		
Heat Treatment		
Testing Machine		
Make	Ivy	Ivy
Capacity	60,000 pound	60,000 pound
Speed	1200 cpm	1200 cpm
	Cut Thread	Ground Thread
Load	52,136#	52,136#
Stress	140,000 psi	140,000 psi
	5,000	9,000
	7,000	11,000
	7,000	11,000
	7,000	12,000
Load	37,240#	37,240#
Stress	100,000 psi	100,000 psi
	11,000	44,000
	11,000	47,000
	17,000	49,000
		71,000
Load	22,344#	
Stress	60,000 psi	
	70,000	
	84,000	
	88,000	

MECHANICAL PROPERTIES

Date December 28, 1957 **For Char. No.** 53

Bolt Description

	Cut Thread		Ground Thread	
Type	Stud		Stud	
Size	3/4-16		3/4-16	
Material	MIL-S-7108		MIL-S-7108	
Bolt Strength Pounds				
	Specimen 1	Specimen 2	Specimen 1	Specimen 2
Ultimate Tensile				
Yield Strength				
Material Strength PSI				
.505 Gage Specimen				
Tensile Strength	251,500	257,500	233,400	232,800
Yield Strength	200,000	200,000	191,000	191,000
Elongation - % in 4 Diameter				
.505 Gage Specimen	10.4	12.0	12.0	11.0
Reduction of Area - %				
.505 Gage Specimen	46.3	47.5	49.5	48.3
Shear Strength - Bolt Body				
Pounds - Double Shear				
PSI				
Fatigue Strength @ 8,000,000 Cycles 10% Low Load				
Pounds				
PSI (Mean Area)				
Lot No.	527		571	



Tension - Tension Fatigue Test
1"-14 STUD
MIL-S-7109 Material - Heat Treatment 220,000-240,000 PSI
Thread Form per MIL-B-7838
Logarithmic Mean Life
Low Load = 10% Maximum Load
Testing Speed = 500 CPM
Chart No.: 54
Date: 12/10/57
Load in Pounds
122,235
108,656
95,074
88,283
STRESS - P.S.I. (Mean thread area)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
CYCLES TO FAILURE
1,000
10,000
100,000
1,000,000
10,000,000

TENSION - TENSION FATIGUE TEST RESULTS

10% Preload - Stress Calculated on Tensile Stress Area

Date: 12-16-57

Bolt Design	Stud
Size	1"-14
Material	MIL-S-7108
Heat Treatment	220,000-240,000 psi
Thread Form	MIL-B-7838
Plate	none
Stress Area	.6791 Square Inches
Nut Type	None
Style	
Material	
Heat Treatment	
Testing Machine	
Make	Amsler
Capacity	220,000 pound
Speed	500 cpm

Maximum Load	135,820#	122,238#	108,656#
Stress	200,000 psi	180,000 psi	160,000 psi
	9,000	11,000	44,800
	10,000	21,000	80,900
	11,400	24,000	105,000
	13,000	30,000	136,000
	15,000	32,000	365,000
Average	11,720	23,600	146,340
Logarithmic Mean Life	11,520	22,140	113,600

Maximum Load	95,074#	88,283#
Stress	140,000 psi	130,000 psi
	973,000	8,000,000 NF
	1,413,300	8,000,000 NF
	1,833,000	
	3,149,700	
	3,561,000	
Average	2,186,000	8,000,000
Logarithmic Mean Life	1,951,000	8,000,000

MECHANICAL PROPERTIES

Date December 9, 1957 For Chart No. 54

Bolt Description

Type	Stud	
Size	1"-14	
Material	Hy Tuf	
Bolt Strength Pounds		
	Specimen 1	Specimen 2
Ultimate Tensile		
Yield Strength		
Material Strength PSI		
.505 Gage Specimen		
Tensile Strength	227,500	222,500
Yield Strength	194,300	195,700
Elongation - % in 4 Diameter		
.505 Gage Specimen	11.3	11.3
Reduction of Area - %		
.505 Gage Specimen	47.7	47.7
Shear Strength - Bolt Body		
Pounds - Double Shear		
PSI		
Fatigue Strength @ 8,000,000 Cycles 10% Low Load		
Pounds		
PSI (Mean Area)	88,283	
Lot No.	244	